Volume 2 Issue 1
January 2000

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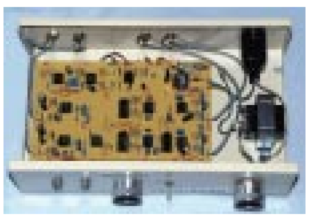
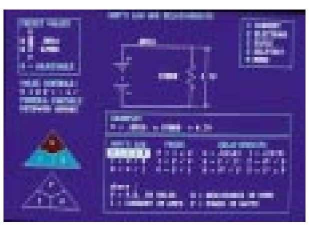


SERIES AND FEATURES



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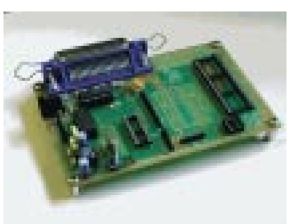

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Editorial

BYGONE MILLENNIUM

As you may have noticed from the advertisements now appearing on the *EPE Online* web site, we have recently taken over publication of *Radio Bygones* magazine. This has introduced us to the fascinating world of early (sometimes very early and very primitive in technology terms) radio equipment. What has impressed us most about these old “wireless” sets is the quality of workmanship that went into them. This not only applies to the chassis and cabinet construction, but also to the construction of individual items like coils and tuning capacitors. I wonder if our descendants will look back on equipment made in the 90s (the 1990s we mean!) and marvel at the quality of our workmanship?

Of course, many early receivers were constructed as one-offs by experimenters and hobbyists, and in the early 1900s there were a number of kits available for constructors. It's fascinating to look back at the roots of our hobby and we will be doing this over an extended period in our forthcoming millennium feature. Starting next month, this is currently titled *The Millennium Before The One We're In Now,* although we might change that if we can dream up something equally quirky but less cumbersome.

WE’VE COME A LONG WAY

This feature brings out some fascinating points about when developments took place. For instance, it is possible that the first rudimentary calculator was dreamed up by Leonardo da Vinci before the pencil had been invented. But obviously most of what is interesting to us electronics folks is what took place from around the turn of the century onwards, with the pace increasing rapidly as the century wore on. It continues to do so, of course, and is presently doubling in speed of development every decade – where will it all end?

We have come a long way from valves and plug-in coils to microprocessors and surface mount devices in a relatively short period, and our hobby has changed along with technology. Though it is of course still possible to build, and get a great deal of pleasure from, a single valve receiver to a 1920s design. we doubt it will be possible to build any of our PIC projects in 20 years time, let alone 80 years time, but that's progress we guess.

MILLENNIUM GREETINGS

And finally, the season's greetings to you all, and may we wish you all the very best for the new millennium. As you know, *EPE Online* has only been around for just over one year, but we’re hoping to be good for the next 1000 so as to see the dawn of the *next* millennium!

Clive Maxfield & Alvin Brown

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Next Month

PIC CONTROLLED VIDEO CLEANER

Macrovision, the VCR to VCR copy-prevention system used on many commercial videotapes, can lead to picture brightness variation when played through some TV sets. This PIC controlled project overcomes the problem.

Using a PIC16F83 and a handful of other components, this self-contained unit is automatic in operation; just plug in the SCART leads and away you go.

TECHNOLOGY TIMELINES

All about how technology developed in the Millennium before the one we'll be in soon. Or as the authors would have it – *Boldly going behind the beyond, behind which no-one has boldly gone behind, beyond, before!*

The 20th Century saw phenomenal technological progress (along with corresponding impacts on our culture). In many respects we've gone from close to nothing (technology-wise) to where we are today in the last 100 years, and many observers feel that our current accomplishments represent only the "tip of the iceberg". Thus, as we enter the 21st Century we are poised on the brink of unimaginable possibilities and potentialities.

The purpose of this new series is to review how we got where we are today (and where we look like ending up tomorrow). We shall first cast our gaze into the depths of time to consider the state of the art as the world was poised to enter the 20th Century. Then, over the coming months, we will take a retrospective view of the technological developments of the last millennium as we investigate the key people and events in three arenas: Physics and Electronics, Communications, and Computers.

During our discussions we shall discover the way in which everything is interrelated, such that inventions in disparate fields can be combined in ways their originators never dreamt of, catapulting us into a future none of us can conceive in our wildest dreams.

Knowing how rapidly things have changed over the last few decades, only a fool would dare to predict the future with any level of confidence. Thus, we shall leave such pontifications to the final installment, where we shall consider emerging new technologies and peer into our crystal balls to cast some predictions for technological advancements over the next 100 years.

THE EASY-TYPIST

This little project was devised to speed the task of typing text into a computer, though it will probably find plenty of other uses. It plays recorded speech a few words at a time, waiting for a prompt before continuing. This allows people who cannot type without looking at the screen or keyboard to type rapidly and continuously since it removes the need to refer frequently to the text being typed, which, in the case of handwriting, can be extremely tedious.

VOLTAGE MONITOR

This simple device has two LED indicators that switch on if the monitored supply voltage falls below separate threshold levels. The obvious application is in battery operated equipment where erroneous results could be obtained if the battery potential falls below a critical level. The twin threshold levels are then useful, as one can be set slightly above the critical voltage, and it will then give a warning if the battery will soon need replacement. The circuit can also be used with mains powered equipment to monitor the DC supply voltage, and it will then give a warning if the supply voltage drops to an inadequate level due to a malfunction. It can be set at any potentials from 3·5V to 30V.

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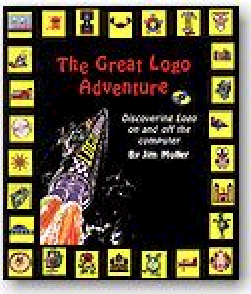
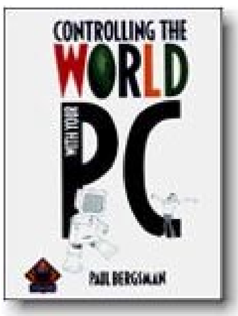
A selection of ELECTRONIC Books for Hobbyist and Students



The Great Logo Adventure

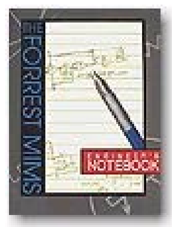
A cartoon-illustrated, family activity book for exploring animation, graphics, math, geometry, ... Ideal for teaching programming concepts to young people of all ages.
FREE CD-ROM (for PCs and Macs) contains Logo software plus lots of other stuff.

More details are available on the EPE Online web site



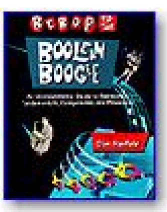
Controlling the World With Your PC

Connect your MS-DOS/Windows PC to the real world with this best-selling book!
Comes with all software (executable files plus C, Basic, and Pascal



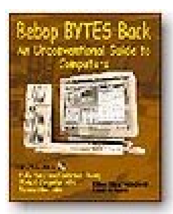
Forrest Mims Engineer's Notebook

This revised edition includes hundreds of useful circuits designed and built by Forrest using commonly available integrated circuits and other components.



Bebop to the Boolean Boogie (An Unconventional Guide to Electronics)

This in-depth, highly readable, up to the minute guide shows you how electronic devices work and how they're made -- the only electronics book where you can learn about musical socks and the best time of the day to eat smoked fish!



Bebop BYTES Back (An Unconventional Guide to Computers)

This follow-on to *Bebop to the Boolean Boogie* is a multimedia extravaganza of information about how computers work.
FREE CD ROM contains the *Beboputer Computer Simulator*, along with over 200 megabytes of mega-cool multimedia.

Visit the EPE Online Store at

www.epemag.com and place your order today!

Constructional Project

FLASHING SNOWMAN by ROBERT PENFOLD

Add a "sparkle" to your festive decorations with this fun starter project.

If you wish to make an electronic project popular you give it some flashing LEDs (light-emitting diodes), or you do if you believe the in-joke that was popular in the electronic magazine publishing business some years ago. This joke came about because one of the magazines now incorporated into *EPE* published a project that was basically just a soap dish fitted with some LEDs that flashed. Apart from looking pretty it did not actually do anything, but that did not stop it from being by far the most popular project ever published by that magazine! This project is very much in the flashing soap dish tradition, and it is just a polystyrene ceiling tile fitted with some LEDs that flash. It is a simple but amusing Christmas decoration that should raise a smile or two.

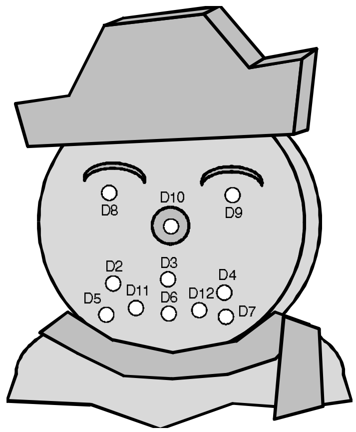


Fig.1. Suggested layout for the LED "face" display.

MR SNOWMAN

The tile is fashioned and painted to look like a Snowman (or Snowperson?), and it has LEDs to form the eyes, nose, and mouth. The LEDs for the eyes and nose are lit continuously, but there are three sets of LEDs to form the mouth. Some are lit continuously, while the other two sets are operated in anti-phase (when one set is switched on the other set is switched off). The idea is to arrange the LEDs so that the Snowman's expression alternates between an internet style smile and frown. This is just a suggestion, and there is plenty of scope for doing your own thing. You could use a different character, such as Father Christmas, as the basis of the project, and he could be made to wink for example.

ON THE FACE OF IT

There are eleven LEDs (D2 to D12) in the suggested configuration, but it is easy to modify the unit to suit alternative arrangements. The LEDs are used in the configuration shown in Fig.1. Light emitting diodes D8 and D9 form the eyes, and D10 is the nose. Together with D11 and D12, these LEDs are lit continuously.

To produce the smiling face, LEDs D2, D3, and D4 are switched on, while D5, D6, and D7 are switched off. To produce the unhappy face D2 to D4 are switched off, and D5 to D7 are switched on.

CIRCUIT OPERATION

In order to operate the flashing LEDs out of phase a low frequency oscillator is required, but it must be capable of handling fairly high output currents. The full circuit diagram for the Flashing Snowman project appears in Fig.2.

Starting with the LEDs that are lit continuously (D8 to D12), these are simply fed from the 9V supply via resistor R7. This resistor limits the current to a suitable level.

Ideally each LED would have its own series resistor, as this would guarantee virtually the same drive current to each one. In practice there seems to be no problem if the LEDs are simply wired in parallel and supplied with current via a common resistor.

This will only work properly if they are all of the same type. Using LEDs of various shapes, colors and sizes would almost certainly result in one or two operating at high brightness and others failing to glow visibly.

RELAXATION

The oscillator is based on operational amplifier IC1 and uses a standard configuration. IC1 is actually connected as a simple trigger circuit, which is then used in a form of relaxation oscillator.

Resistors R1 and R2 bias the non-inverting input (pin 3) to half the supply voltage, and normally the output, at pin 6, would go low if the inverting input (pin

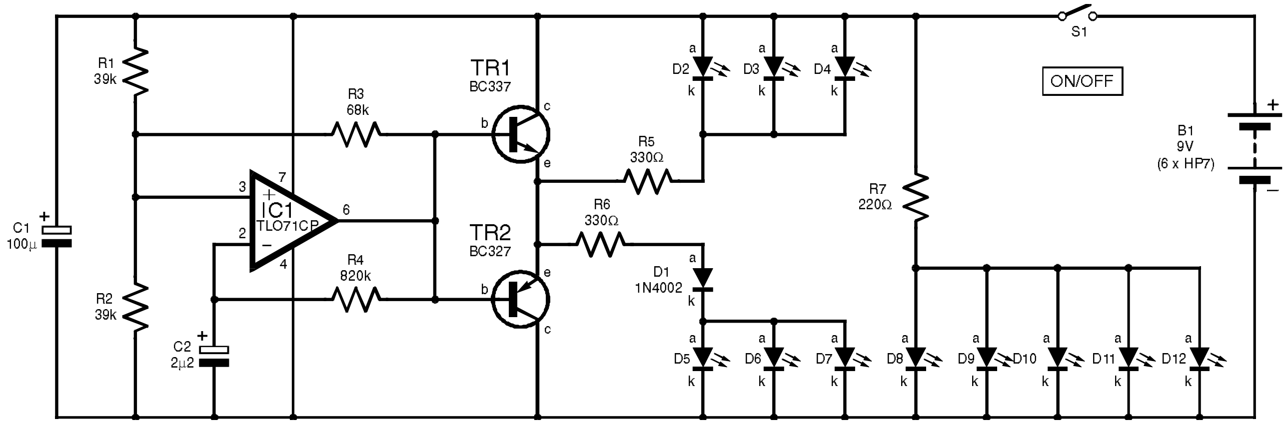


Fig.2. Complete circuit diagram for the Flashing Snowman.

2) was taken above this potential. Taking the inverting input *below* this bias level would send the output high. In this case there is positive feedback from the output to the non-inverting input via resistor R3.

This feedback takes the bias level higher when output of IC1 is high, and lower when it is low. Consequently, there are actually two threshold levels. Taking the inverting input below the lower threshold sends the output high, and taking it above the higher threshold sends the output low.

Adding a *C/R* timing circuit (R4 and C2) between the output of IC1 and its inverting input produces oscillation. At switch-on capacitor C2 is fully discharged and the inverting input is at the lower potential, which sends the output high. Capacitor C2 then charges, via resistor R4, until the charge potential exceeds the upper threshold level of the trigger circuit.

The output of IC1 now goes low and C2 discharges through R4 and the output circuit of IC1 until the potential goes below the trigger circuit's lower threshold level. The output of IC1 then goes high again, C2 charges via R4 until the upper threshold is exceeded, and so on.

The circuit oscillates continuously at a rate that is governed by the values of various components, but primarily by the timing resistor R4 and capacitor C2. The specified values set the operating frequency at a little under 1Hz, which means that the flashing LEDs are switched on for about half a second or so, and then off for about the same period of time.

IN A FLASH

The flash rate is easily changed by altering the value of C2 and/or R4. The on/off time is proportional to the value of both timing components, so extending this time to (say) one second could be achieved by doubling the value of either component.

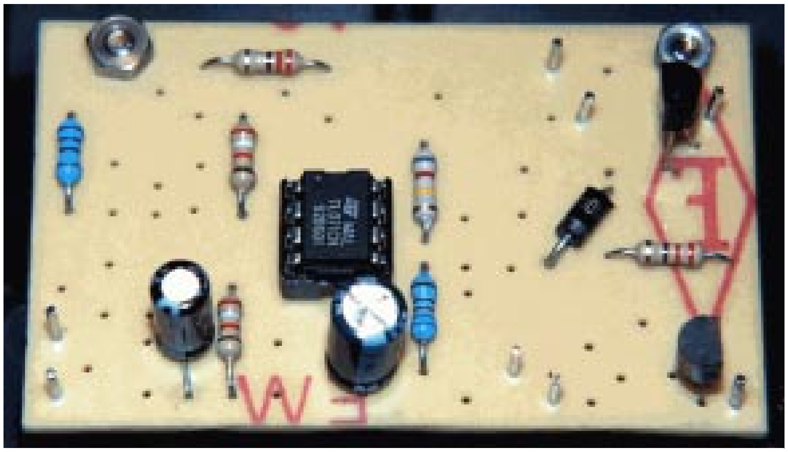
In practice it is necessary to compromise slightly and use the nearest preferred value, which is 4·7uF for capacitor C2 or 1·5M for resistor R4. Note that C2 ***must*** be a good quality component or the operating frequency will be much lower than expected, if the circuit manages to oscillate at all. There should be no problems with the specified timing component values, but if a much lower frequency is used it would be best to use a tantalum capacitor for C2.

An output current of about 5mA per LED is required in order to produce reasonable brightness. Six LEDs are driven from the output of the unit, but only three are switched on at any one time. The maximum output current is therefore 15mA, but could be about 25mA to 30mA if the unit is used to drive more LEDs.

This is more than opamp IC1 can reliably supply, and a simple emitter follower output stage (transistors TR1 and TR2) has therefore been added at the output. The output stage is a sort of simplified version of a class-B audio output stage.

Transistor TR1 acts as the emitter follower output stage when the output of IC1 is high and LEDs D5 to D7 are switched on. TR2 acts as the output stage when the output of IC1 is low and LEDs D2 to D4 are switched on. R5 and R6 are the current limiter resistors for the two sets of LEDs.

When the output of the circuit is low, the output voltage is still high enough to produce a slight glow from LEDs D5 to D7. Recti-



Component layout on the completed multi-project circuit board.

fier diode D1 is used to effectively reduce the minimum output voltage by about 0·6V, so that D5 to D7 fully switch off when IC1's output is low.

STABLE SUPPLY

The current consumption of the main circuit is about 20mA, but the consumption of the non-flashing LEDs adds about 25 milliamps to this. The circuit can be powered from a reasonably high capacity battery, such as six HP7 size cells in a holder, *but **NOT** a small type such as a PP3.*

Alternatively, the circuit seems to work well when powered from a *stabilized* mains adapter that will provide 9V at around 50mA or more. This is the more practical option if the unit will be used for long periods.

Table 1. LED series resistor values.

No. LEDs	Resistor Values (R5/R6/R7)
1	1k
2	470 ohms
3	330 ohms
4	270 ohms
5	220 ohms
6	180 ohms

If you decide to use such an adapter, make sure it is connected to the unit with the right polarity. Most adapters are marked with diagrams showing the polarity of the supply lead, and the polarity might be switchable.

Non-stabilized adapters are not recommended for use with this circuit. Units of this type have output voltages that vary greatly with changes in the output current, and the actual output voltage is often very much higher than the stated output potential.

A BRIGHT NUMBER

The number of fixed state and flashing LEDs can be altered to suit alternative designs, but the value of the series resistor (R5, R6, or R7) should be changed to suit the number of LEDs wired in parallel. This will keep the brightness of the LEDs reasonably uniform. Table 1 shows suitable values for one to six LEDs.

CONSTRUCTION

This "easy" starter project is based on the *EPE* multi-project printed circuit board (PCB). This board is available from the *EPE Online Store* (code 7000932) at **www.epemag.com**

The components fit onto this PCB with few difficulties, because the board was designed to take this oscillator configuration and output stage. Even so, the usual warning has to be given as follows: Unlike a normal custom printed circuit board, the multi-project board has numerous holes that are unused. This makes it a little trickier to get all the components in the right place, and it is essential to take a little more care than usual when fitting the components on the PCB, and to double-check the finished board for errors.

In all other respects construction of the board is per-

COMPONENTS

Resistors
R1, R2 39k (2 off)
R3 68k
R4 820k
R5,R6 330 ohms (2 off)
R7 220 ohms
All 0.25W 5% carbon film

Capacitors
C1 100u radial electrolytic, 10V
C2 2u2 radial electrolytic, 50V

Semiconductors
IC1 TL071CP bi-FET opamp
TR1 BC337 silicon *npn* transistor
TR2 BC327 silicon *pnp* transistor
D1 1N4002 rectifier diode
D2 to D12 5mm red LED (11 off)

Miscellaneous
S1 s.p.s.t. miniature toggle switch
B1 9V battery pack (6 x HP7 cells in holder)

Multi-project circuit board available from the *EPE Online Store*, code 7000932 (**www.epemag.com**); small plastic case, size to suit; battery connector (PP3 type); 8-pin DIL socket; multistrand connecting wire; single-sided solder pins; solder; polystyrene ceiling tile, etc.

See also the SHOP TALK Page!

Approx. Cost Guidance Only (Excl. batts, case, & tile) **$11**

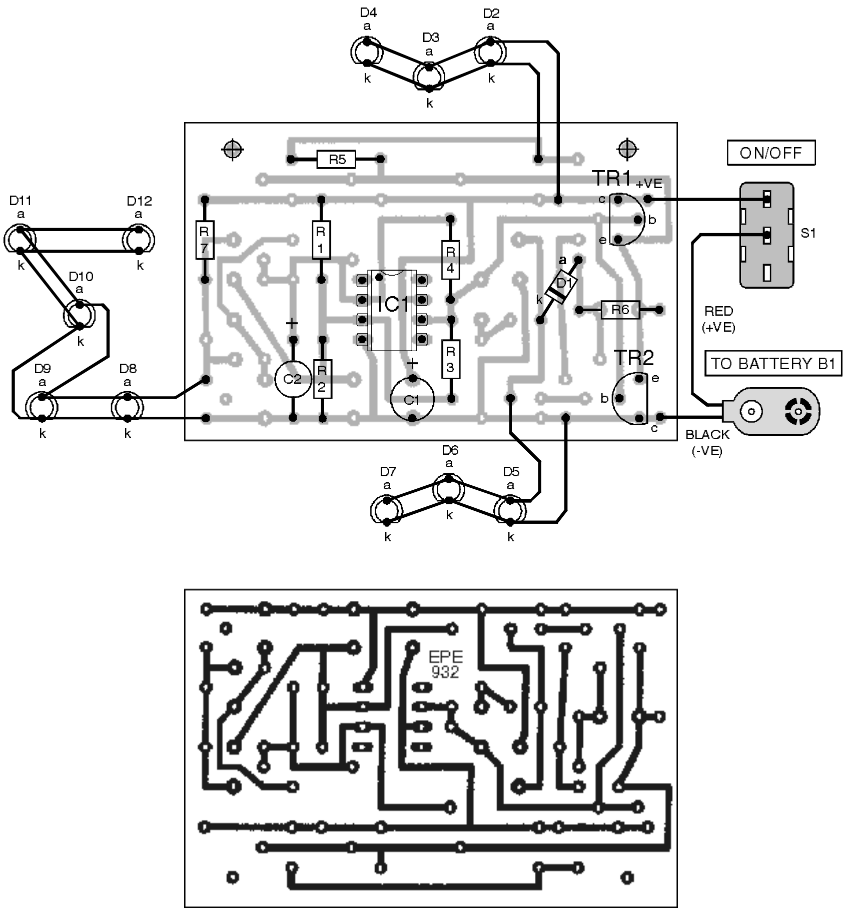


Fig.3. Snowman multi-project PCB component layout, interwiring, and (approximately) full-size copper foil master. Take care, not all holes/pads are used.

fectly straightforward and should follow along the normal lines, starting with the resistors, capacitors, diode and, finally, the two transistors. The component layout is shown in Fig.3, together with the actual size copper foil pattern and interwiring details. Fit single-sided solder pins to the board at the points where it will connect to the battery, on/off switch S1, and the LED display.

The TL071CP opamp used for IC1 is not a static sensitive component, but it is still a good idea to mount it on the board via an IC holder. Be careful to fit diode D1, transistors TR1/TR2, opamp IC1 and the two electrolytic capacitors the correct way round on the PCB.

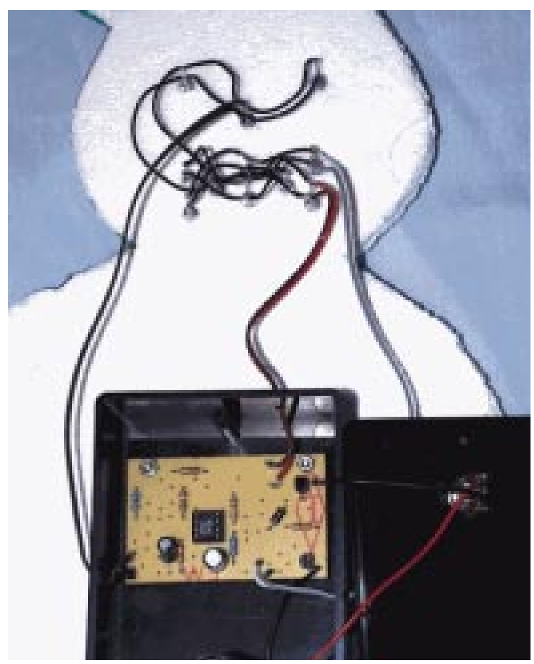
CASING UP

Virtually any small plastic or metal box should accommodate this project, but if the unit is battery powered be careful to select a case that is large enough to take the rather chunky battery pack. Incidentally, the connections to the battery holder are made using an ordinary PP3 battery clip.

The printed circuit board is mounted on the case using 6BA or metric M2·5 bolts, with short spacers included between the board and the case. On/Off switch S1 is mounted on the lid of the case. Drill small holes in the case sides to take the three twin-leads that will carry the output of the unit to the three sets of "face" LEDs. The small amount of hard wiring is added next. Fit leads, about 300mm long, on the three sets of output solder pins. These leads can be trimmed to length and prepared for connection to the LEDs once the body of the Snowman has been completed.

SHAPING UP

The body of the Snowman (or other character) does not have to be made from a polystyrene ceiling tile, but this material has the advantage of being easy to cut into awkward shapes. It is a bit brittle, but with care the expanded polystyrene can be cut using scissors, or a sharp modeling knife is also suitable.



Wiring to the LED display and to the PCB mounted inside the small box. Allow space for the battery pack.

The two faces of Mr. Snowman – a "snowfall" and a "thaw"!

A more substantial material such as plywood or MDF is equally suitable or perhaps even better than expanded polystyrene, but a jig-saw is needed to cut these tougher materials to shape. There is no need to get too clever when making the body of the unit, and with this type of thing something simple and basic often works best.

When using plywood or MDF the LEDs are mounted in 5mm diameter holes, and they are glued in place using any good quality general-purpose adhesive. With expanded polystyrene the best approach is to make small holes and then *gently* push the LEDs into position.

The natural sponginess of the material holds the LEDs in place quite well, but they can still be glued if preferred. However, many adhesives attack polystyrene, and the hot glue from glue guns tends to melt the polystyrene. A quickset epoxy adhesive is probably the best type to use.

WIRING UP

Wiring up the LEDs is much easier if you give them a uniform orientation, such as having all the cathode (k) terminals towards the bottom. This helps to keep the wiring neat and you can tell at a glance which lead is which.

The LEDs will almost certainly be supplied with quite long leads, and they will have to be trimmed back to a length of about 10mm. The polarity is usually indicated by the cathode lead being slightly shorter than the anode lead, and it is advisable to keep this disparity. Also, the cathode is often indicated by a "flat" on that side of the body, but this is something less than universal.

There is some advantage in using LEDs that are red when switched on, but clear when switched off. These blend into the background better when switched off, and give a slightly more convincing effect.

The wiring is completed using ordinary multistrand connecting wire. Wire up the three sets of LEDs one set at a time, following the wiring pattern shown in Fig.3. The easiest way of tackling this job is to use a single wire to connect each set of anodes and cathodes. This means making some connections along the length of the wire and not just at the ends. This is much easier using non-insulated wire, but pieces of sleeving must then be added onto the wires to ensure that accidental short circuits are avoided.

An easier alternative is to use ordinary connecting wire, with wire strippers being used to cut through the insulation at the points where connections will be made. The insulation can then be opened out slightly, so that the exposed wire can be "tinned" with solder. With the ends of the leadout wires "tinned" with solder as well, the wire should readily connect to the leadouts.

FINAL TOUCH

The case containing the electronics must be mounted on the rear of the "body", and double-sided adhesive pads are probably the best way of doing this. The traditional hat, scarf, eyebrows, and buttons must be painted onto the Snowman. Artists' acrylic paints are good for this, but fibre-tip pens provide a good low cost alternative.

To complete the unit the leads from the circuit board are trimmed to length and connected to the display, being careful to connect them with the right polarity. A double-sided adhesive pad is probably the best way of doing this.

The unit is then ready for testing, and if all is well some of the LEDs should light up at switch-on, followed by the simple animation effect. If there is any sign of a fault switch off at once and recheck the wiring.

If one set of LEDs fails to operate there is probably a short circuit at the connections to one of the LEDs in that set. Alternatively, the LEDs could be connected to the circuit board with the wrong polarity. If one LED in a set fails to work, that LED is faulty or connected with the wrong polarity.

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A selection of ELECTRONIC CD-ROMS for Hobbyist and Students

Computer Desktop Encyclopedia

The award-winning source of computer terms, concepts, important products and interesting stuff!! An invaluable reference and an unmatched resource for anyone interested in computers. **($14.99 Special Offer! -- While Stocks Last!)**

The PhizzyB Computer Simulator

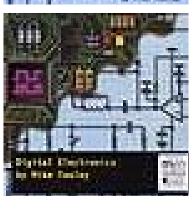
The *PhizzyB Simulator* provides an accurate representation of the real *PhizzyB*, including the ability to step and run through programs. Comes equipped with an assembler and other tools, plus user manuals (as PDF files on the CD ROM).

PICtutor by John Becker

This CD-ROM, together with the PICtutor development board (as described when you click on "more info"), will teach you how to use PIC microcontrollers. The board also acts as a development test bed and programmer for future projects.

Electronic Circuits & Components

This CD provides an introduction to the principles and application of the most common types of electronic components, and shows how they are used to form circuits. The CD also includes the "Parts Gallery".

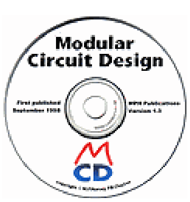


Digital Electronics (Mike Tooley)

This CD builds on the knowledge of logic gates covered on the Electronic Circuits and Components CD (described above), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors

Analog Electronics (Mike Tooley)

This is a complete learning resource for the most difficult branch of electronics. The CD includes a host of virtual laboratories, animations, diagrams, photos, and text, as well as a SPICE electronic circuit simulator with over



Modular Circuit Design

This "web on a CD"-based educational software package contains essential information for anyone undertaking high school-level electronics or technology courses, and for hobbyists who want to get to grips with project design..

Visit the EPE Online Store at
www.epemag.com and place your order today!

Constructional Project

VERSATILE BURGLAR ALARM

by IAN MARCH

An easy-to-construct and install "closed-loop" alarm that is readily extendable. Ideal as a secondary back-up system.

A burglar alarm system can be as complicated or as simple as you wish. The need was for one that would offer a good degree of protection, without being horrendously awkward to install or operate.

It was decided, therefore, that no attempt would be made to detect an initial entry, since this would entail a switch on every outside door and window frame, and glass break detectors on panes of glass. Instead, sundry internal doors would be alarmed. This has the advantage of not requiring a delayed arming system, to cover exit after setting the alarm, or a delayed actuation, to allow the returning owner to disarm the system.

If the owner has followed police guidelines and fitted a mortice lock to the front door, any attempt at entry, once the usual "lock picking" attack on the front door has failed, would most likely be made at the rear of the property. At the side and rear, PIR-operated floodlights provide some deterrence, although, of course, they will not see off the determined professional housebreaker, or have any effect during daylight hours when most burglaries are carried out.

SYSTEM FACILITIES

The preferred system finished up using a simple series-loop of door switches. A small "Form A" n.o. (normally open) reed relay was recessed into each alarmed doorframe, as near floor level as practicable. Then an operating magnet was let into the edge of the door, closing the switch when the door is shut.

A further consideration was that two cats should have the run of the house downstairs, and also the stairs and landing, but not any of the upstairs rooms. So the switches were fitted to all the doors opening onto the landing – namely the bedrooms and the bathroom.

However, if pets do not feature in your household, some or all of the downstairs internal doors can be included in the loop. But upstairs switches only

Features . . .

Does not require front door to be alarmed.

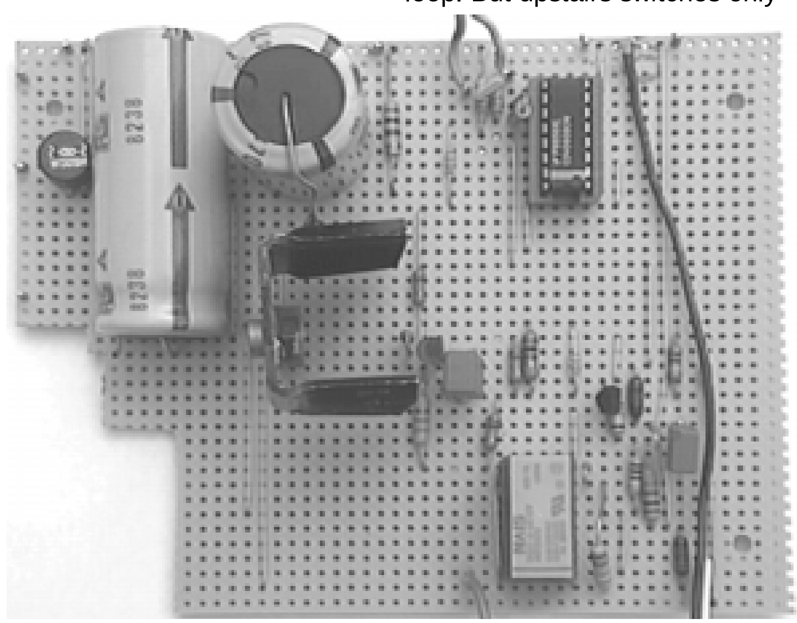
No need to exit in so many seconds after activating.

No need to rush to switch off when returning.

Meets local (UK) authority bylaws – automatic switch-off after less than 20 minutes.

Extendable if and when desired – additional door and/or window switches; PIR sensor; glass-break detectors, etc.

Includes Test facility to check system is operational.



Component layout on the completed prototype circuit board. The final layout may differ slightly from this.

are probably adequate, as a burglar invariably makes for the main bedroom where, traditionally, any valuables are kept. (But be aware that valuables in unprotected rooms could be removed or rooms ransacked before the alarm is triggered.)

This conveniently confined all wiring to the first floor, concealed under the edge of the fitted carpet on the landing. The control box containing all the electronics is neatly tucked away out of sight under the rear of a chest of drawers on the landing.

Two switches are provided on the Control Box. The On/Off (Reset) switch enables or disables the alarm, and also resets it if the alarm has been activated. The alarm itself can consist of an internal high power klaxon, an external bell, and/or a flashing strobe light.

All three were fitted in the author's system, with the klaxon at ceiling level in the hall, by the front door. Outside, a translucent weatherproof box above the porch in an obvious "easy-to-see" position to act as a deterrent, houses the bell and strobe.

The other switch provides Normal and Test positions. In the Normal position, when the alarm is activated, it operates for some 15 minutes (or until Reset). In the Test position, if an alarmed door is opened while the system is On, a buzzer in the control box sounds instead, for a brief three seconds, showing that all systems are GO!

CIRCUIT OPERATION

The circuit diagrams that make up the *Versatile Burglar Alarm*, together with the power supply, are shown in Fig.1 and Fig.2. **(Note that this power supply is designed for use with the UK's mains supply – readers in other countries will have to modify it accordingly, in which case it is recommended that you consult a qualified electrician).** Assuming all the door sensor switches are closed, switch S1 is set to On (open circuit), and S2 is at Normal (Fig.1), circuit operation is as follows.

If any of the alarmed doors are opened, resistor R1 applies a positive-going edge, via R2, C1, D2 and R8, to the base (b) of transistor TR1. This operates the relay RLA, which in turn maintains the transistor in conduction, via self-hold contact RLA1. Relay contact RLA2 applies 12V DC power to the internal klaxon, and outside bell and strobe – see Fig.2.

The positive-going edge is also applied via R3 to the Reset of IC1, pin12, setting all the counter stages to logic 0. The positive edge then dies away, as capacitor C1 charges up. Output Q14 at pin 3 of IC1 having been set to logic 0, the device's internal oscillator starts to run, as it is no longer disabled via diode D3. On reaching the count of 213, pin 3 of IC1 returns to the high level, inhibiting the oscillator section of the device.

This positive-going edge at IC1 pin 3 turns on transistor TR2, and via C4, R14 and D5 momentarily turns off TR1, causing the relay to drop out and removing the self-hold action of RLA1. Thus the klaxon, bell and strobe cease to operate; having been energized (with the component values shown) for a period of not more than 20 minutes.

This self-canceling action is a requirement of most local authority bylaws. In the event of the owner returning to find the alarm sounding, it can be cancelled immediately by setting switch S1 to Off (Reset).

Operation with switch S2 in the Test position is the same, apart from two crucial differences. First, S2 enables the control unit's internal buzzer WD1, rather than the klaxon, etc. Second, with the oscillator timing capacitor reduced to 180pF (C3), the Q14 output terminates the sounding period after some three seconds.

COMPONENTS

A full list of components is given, but many readers will, no doubt, have most of the smaller components in stock. For example, the mains transformer used in the prototype was a 20VA unit, with two 6·3V AC secondaries, salvaged from an old valve job.

The larger components, such as the klaxon, bell, and strobe will probably have to be bought in, but can be added piecemeal at a later date, after the system has been constructed, installed and tested. Obviously, it will pay to use only good quality components, to minimize the possibility of embarrassing false alarms!

CONSTRUCTION

The average constructor may well have a suitable enclosure in stock, perhaps left over from some previous project. Bizarre as it may seem, the prototype was constructed in the wooden case of an old home-made transistor portable radio, about 230mm wide, by 152mm by 152mm, with the original On/Off switch used as

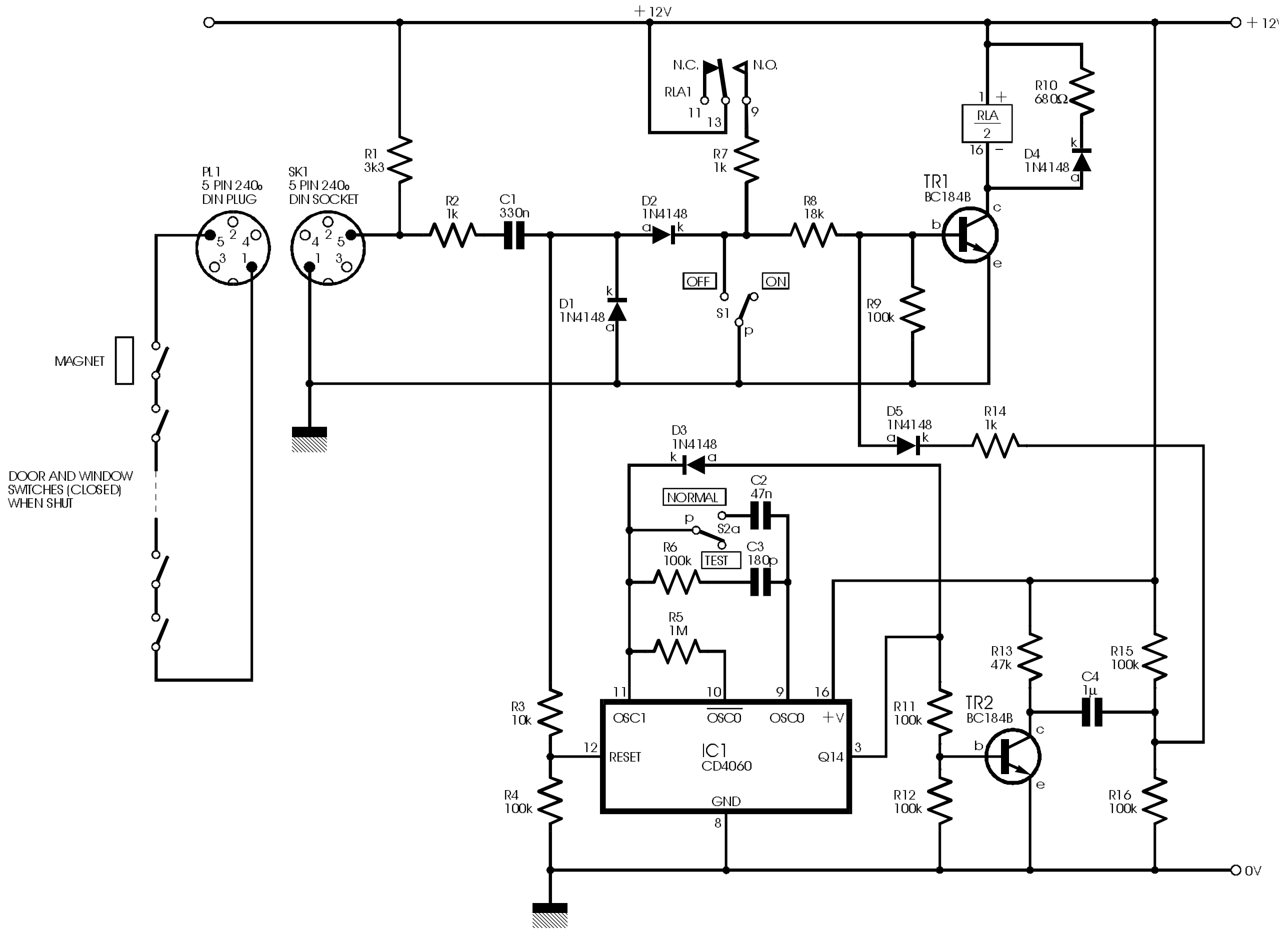


Fig.1. Circuit diagram for the control section and "closed-loop" sensor switching for the Versatile Burglar Alarm.

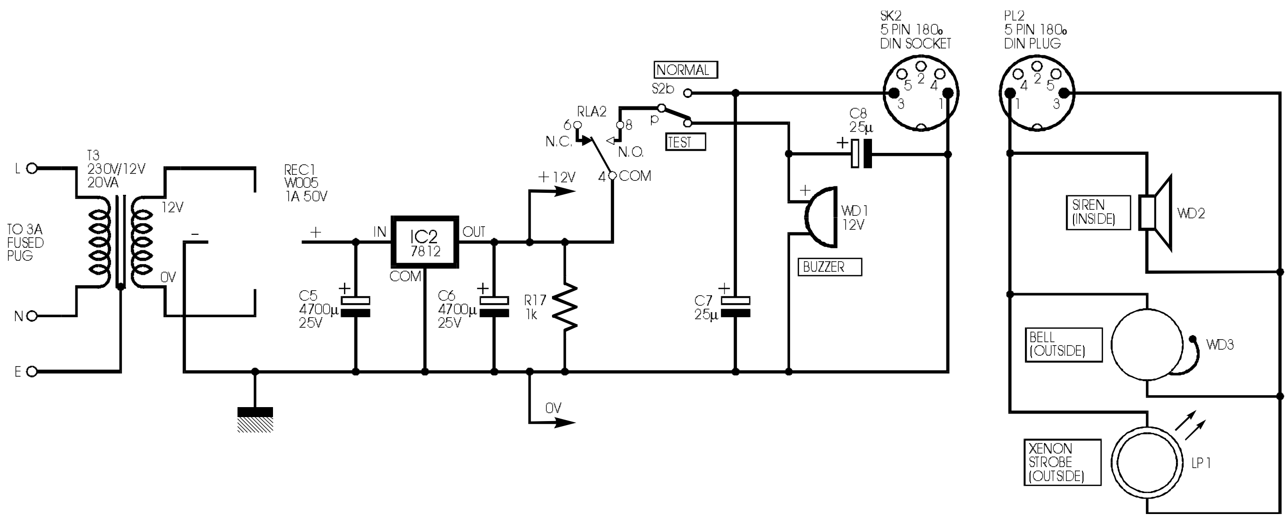


Fig. 2. Circuit diagram for the alarm system power supply and the alarm sirens.

S1. Switch S2 was mounted on the side of the cabinet, and the two sockets and mains lead at the rear.

From the outside, it still looks like its former self! Otherwise, any box of about the stated dimensions will prove suitable.

Two 5-pin DIN connectors were used for sockets SK1 and SK2 as these happened to be in stock. Any 2-pin connector will

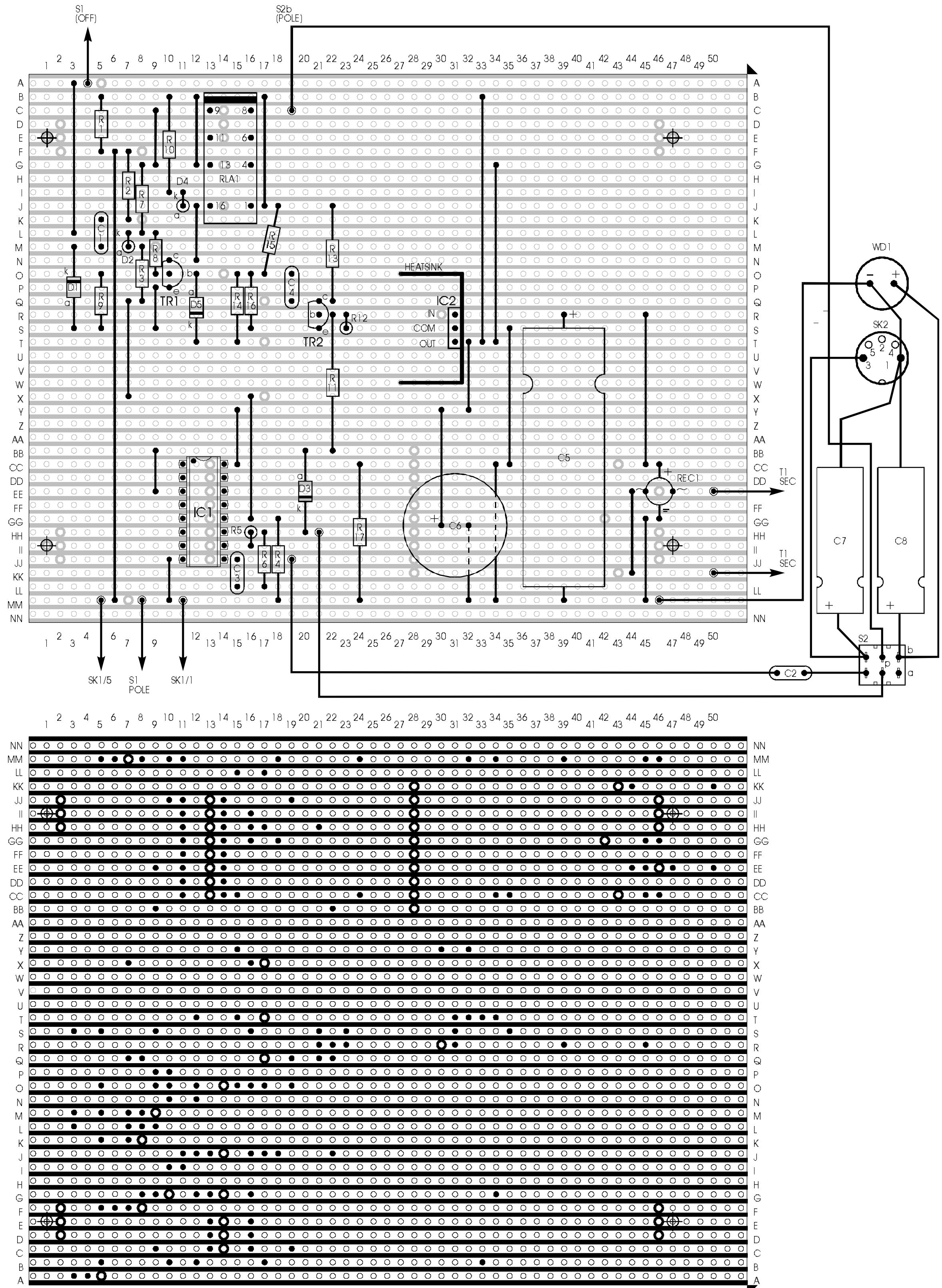


Fig.3. Stripboard component layout and details of breaks required in the underside copper strips. Wiring to the mains transformer, switches and sockets will depend on types used. Capacitors C2, C7, and C8 are wired directly to off-board components.

do for SK1, but SK2 *must* be a non-reversible type, to ensure that the 12V DC is applied to the klaxon, bell and strobe in the correct polarity.

The circuit was built up on 0·1in. matrix copper stripboard, as it was developed. The layout of the prototype is therefore not the tidiest, but the circuit is not critical in this respect. The topside component layout and details of breaks required in the underside copper tracks are shown in Fig.3.

All the components, except the mains transformer, switches, sockets, and buzzer, were mounted on the stripboard, with the following further exceptions. Capacitor C2 was mounted directly on switch S2, C7 between S2 and a common earth point on the stripboard and C8 directly across the buzzer terminals. Counter IC1 was fitted in a 16-pin IC socket, the relay in a 14-pin IC socket, and IC2 was provided with a TO220 twisted-vane heatsink. Note that the TO92 plastic transistors TR1 and TR2 are the variety where the center lead is the base (b) connection, **BC184B**; *NOT BC184L* where the center lead is the collector.

COMPONENTS

Resistors

R1 3k3
R2, R7, R14, R17 1k (4 off)
R3 10k
R4, R6, R9, R11, R12, R15, R16 100k (7 off)
R5 1M
R8 18k
R10 680 ohms
R13 47k
All 0.25W 5% metal film

See also the SHOP TALK Page!

Capacitors

C1 330n polyester
C2 47n polyester
C3 180p ceramic
C4 1u polyester
C5, C6 4700u axial electrolytic, 25V (2 off)
C7, C8 25u axial electrolytic, 25V (2 off)

Semiconductors

D1 to D5 1N4148 signal diodes (5 off)
REC1 50V 1A bridge rectifier
TR1, TR2 BC184B *npn* transistors (2 off)
IC1 4060 14-stage counter-oscillator
IC2 7812 1A 12V voltage regulator

Miscellaneous

S1 s.p.s.t. toggle switch
S2 d.p.d.t. toggle switch
SK1/PL1 5-pin 240º DIN socket and plug
SK2/PL2 5-pin 180º DIN socket and plug
RLA 1A 12V coil 2-pole miniature changeover relay
T1 20VA mains transformer, 12V secondary
WD1 12V piezoelectric buzzer

Case for control unit, approx. size 230mm x 152mm x 152mm; stripboard, 0.1in matrix, size 53 holes x 40 copper strips; 14-pin DIL socket; 16-pin DIL socket; fused (3A) mains plug and lead; multistrand connecting wire; solder pins, solder, etc.

Alarm Devices

WD2 12V piezo siren
WD3 9V to 15V alarm bell
LP1 12V DC xenon beacon

Bell enclosure; miniature reed relay with operating magnet (one of each required per alarmed door)

Approx. Cost Guidance Only *(Excluding alarm devices)* **$45**

TESTING

Testing is straightforward, but is most conveniently carried out on the workbench, rather than in situ. ***However, as a mains supply is involved, great care is necessary. Make sure that all mains connections, including the primary terminals of mains transformer T1 are well insulated, and always disconnect the mains lead from the supply* before *working on or touching any part of the unit.***

Having double-checked all your wiring and tested with a multimeter for any possible shorts across the +12V rail, connect a “test” toggle switch, set to On, temporarily across DIN plug PL1, in place of the sensor loop switches. Set switch S2 to Test and S1 to Off/(Reset).

Connect up to the mains, switch on and check that the raw supply voltage across capacitor C5 is in the range +15V to +18V, depending upon the particular mains transformer used. Check that the stabilized +12V rail is present and correct.

Now set S1 to On and then switch off the “test” toggle switch temporarily attached to plug PL1. The buzzer should sound for approximately 3 seconds. This shows that the unit is basically working.

Disconnect the mains, and wait 20 seconds for resistor R17 to discharge the supply capacitors. Now temporarily short the Normal and Test terminals of S2a and leave switch S2 in the Normal position, so that capacitor C2 is now in circuit. Reconnect the short circuit (switch on test switch) at PL1, set S1 to Off and reconnect the mains. Now set S1 to On and then switch off the toggle switch at PL1. This time, the buzzer should sound for about 15 minutes.

Repeat the above test, checking after a minute or so that setting S1 to Off terminates the alarm. This completes the testing, so the short at S2 can be removed and the unit boxed up and installed.

It only remains to check that, with all the alarmed doors shut and S1 at On, opening any of the doors triggers the alarm. This can be done initially with S2 at Test, but must of course be repeated with S2 at Normal, to check that the klaxon and bell really do sound, and that the strobe light (if fitted) does flash. As soon as this has been shown to be OK, S1 can be set to Off, mercifully terminating the racket!

USING THE ALARM

Using the *Versatile Burglar Alarm* is very simple, no dash from the front door to turn it off again when you come home. When leaving, close all the alarmed doors, check that the unit is plugged in and the mains is on, and set switch S1 to On. Now, opening any alarmed door will trigger the alarm.

Before leaving the house, make sure that switch S2 is at Normal. On your return, remember to set S1 to Off, before opening any of the alarmed doors. If you forget, and activate the alarm, setting S1 to Off will silence it immediately.

It is a good idea to set S2 to Test occasionally, and check that the system is working by opening any of the alarmed doors. This should be done on a regular basis. You can leave S2 in the Test position except when going out, as a matter of course, if you want. If all the alarmed doors are normally kept closed, the system will be tested every time one is opened, as indicated by a discreet 3 seconds buzz.

FURTHER FACILITIES

The "closed-circuit loop" may be extended at any time, to additional door and/or window switches, including the front door. It would also be possible to link the unit to a PIR (passive infrared) sensor fitted, say, in the hall.

This can be problematic in a household including pets, especially large dogs. However, with cats a sensitivity setting can usually be found which will ignore them, but detect humans. Other sensors, such as an IR beam across the hall at waist height, can be used where necessary.

Another possibility is the addition of a 12V backup battery, to maintain operability in the event of temporary mains failure. This has not been included in the present system, since mains failures are nowadays virtually unheard-of in the UK. But some readers living in sensitive areas may wish to add a float-charged battery to the system.

Go to next section

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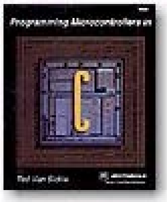

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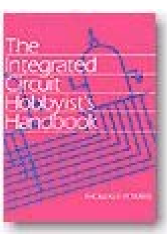

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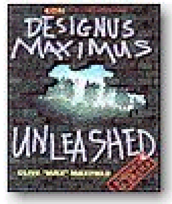

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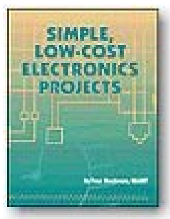

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Constructional Project

SCRATCH BLANKER by ROBERT PENFOLD

A high-class "spin-doctor" for your aging collection of classic vinyl discs.

It seems that reports of the death of vinyl discs have been somewhat exaggerated. While it is true that new vinyl records are not made in significant numbers any more, there is a thriving second-hand market. In fact many types of record are now hotly collected, including some that were manufactured quite recently.

Interest in vinyl records may still be quite strong, but the drawbacks that resulted in compact discs taking over have not gone away. Noise caused by dust getting into the grooves is one problem, but with proper care and handling this can be minimized

Physical damage to this very vulnerable form of recording is probably the main problem, and there is no easy solution to this one. Most new vinyl recordings were supplied complete with a few "clicks" and "pops", and even when handled with due care they tend to gain some more over the years.

SCRATCHING AROUND

Digital signal processing continues to progress, and some "golden oldie" recordings of the 1940s and earlier have been given remarkable "clean-ups" using this technology. Unfortunately, as far as we are aware, there is no, reasonably priced, digital signal processing unit yet available that will take a signal from a vinyl recording and process it to give "click" and "hiss" free reproduction. At the moment the only practical method of combating "clicks" and "pops" is to use analog signal processing.

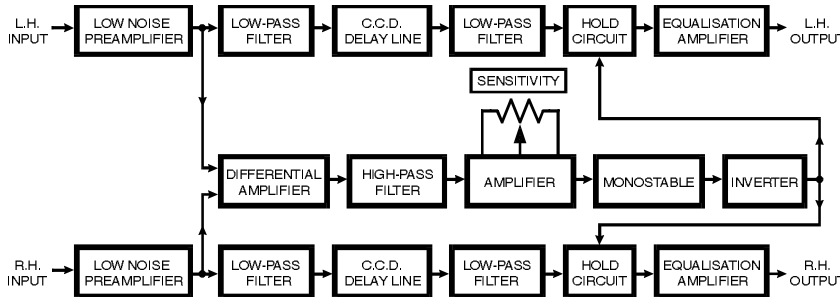


Fig.1. Full block diagram for the Scratch Blanker.

Minor surface noise can be greatly reduced by using simple top cut filtering, although this inevitably removes some of the high frequency content in the recording as well. Larger scratches produce strong signals at frequencies well into the middle audio range, and simple filtering is not a viable option. Filtering that would greatly reduce the noise spikes would also remove most of the main signal!

Analog signal processing can be used to significantly reduce the larger "pops" and "cracks" using blanking or switch-around techniques. With the switch-around technique the output signal is normally delayed by a few milliseconds.

When a click is detected, the circuit waits for the noise pulses to end on the non-

delayed signal. A changeover is then made so that the listener hears the non-delayed signal, avoiding the "click" which by then has completely passed.

After a delay of perhaps a hundred milli-seconds or so, the unit switches back to the original set-up with the listener hearing the delayed signal. Of course, by this time the click has also passed on the delayed signal. What is actually happening here is that the signal is being shortened slightly, with the section around the click being removed.

To make up for this missing signal, a few milliseconds are repeated when the unit switches back to its normal state. This system works well, but there is a danger of two slight glitches being audible as it switches around the click.

SCRATCH BLANKER

The more simple method adopted here is a straightforward blanking approach. The listener again hears what is actually a slightly delayed version of the signal, but with this system a delay of under a milli-second is adequate. This minute delay is needed to give the unit time to detect the click before it starts to appear at the output.

When a click is detected the audio signal is switched off, and it is held off for slightly longer than the duration of the noise caused by a bad scratch. In other words, the click and the signal immediately either side of it is replaced by silence.

Although one might reasonably expect the gap in the signal would be clearly audible, provided the blanking period is no more than about 10 milliseconds it will not be perceived as a gap in the signal. It may be heard as a slight glitch, or it might be "invisible" to the listener.

This all depends on the nature of the signal and the relative signal voltages at the beginning and end of the blanking period. Even if a slight glitch can be perceived, it will be nothing like as disconcerting as the noise pulses it replaces.

DESIGN CONSIDERATIONS

This *Scratch Blanker* project is designed to be fed direct from a *magnetic* pickup, and its output feeds into a high level input of the power amplifier such as a Tape, Tuner, or Aux input. With many hi-fi amplifiers it is possible to extract the output signal from the RIAA preamplifier, process it in some way, and then feed the signal into the power amplifier.

This offers what is undoubtedly a more simple approach, but there are definite advantages to having the preamplifier built into the *Scratch Blanker*. One of these is simply that the system is not reliant on the existing audio equipment having some form of preamplifier output and power amplifier input arrangement. This *Scratch Blanker* should work with any power amplifier that has a spare high level input.

Another advantage of this approach is that it helps to reduce the noise and distortion produced through the delay-line. Noise is not a major problem as only a short delay is required, and the

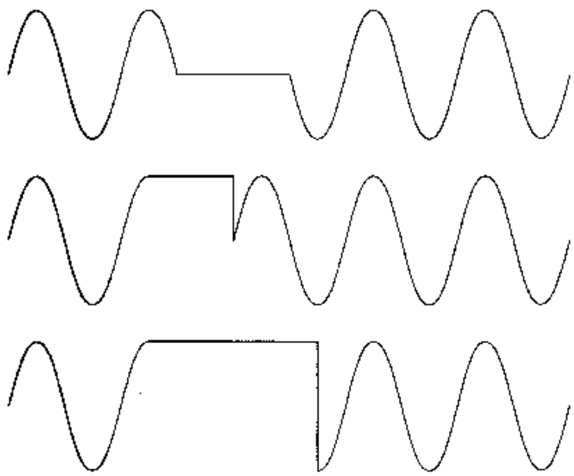


Fig.2. Ideally the blanking pulse would last for one cycle (top), but in practice this will not normally happen.

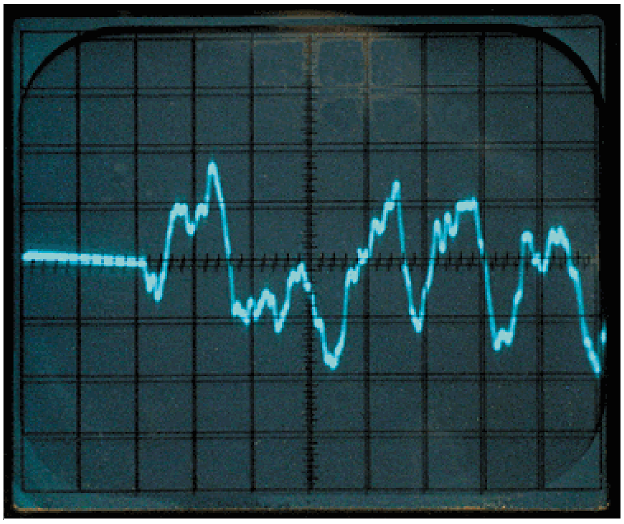


Fig.3. The initial part of the waveform shows the effect of the blanking process.

delay-line chip provides good performance under these conditions. Its distortion performance is also quite good.

However, it could still significantly degrade the performance of the system. In order to provide a flat overall frequency response a RIAA preamplifier must provide a 6dB per octave roll-off above 2120Hz, and a 6dB per octave boost from 500Hz to 50Hz. By placing the equalization stage at the output of the blanker the high frequency roll-off helps to counteract noise and distortion through the delay-line, and also helps to minimize any slight switching glitches produced by the blanking process itself.

SYSTEM OPERATION

The block diagram of Fig.1 shows a slightly simplified version of the arrangement used in this *Scratch Blanker*. Each stereo channel is processed by an identical series of stages, so here we will only consider one channel.

The output level from a magnetic cartridge is quite low, and is typically just a few millivolts RMS. A Low Noise Preamplifier at the input boosts the signal to a level that gives better noise performance from the delay-line.

It is important that high frequency signals are not allowed to enter the delay-line as they could react with the clock signal to produce audible heterodynes on the output. In theory there will be no input signals at these frequencies anyway, but in practice there can be problems with stray pick-up of radio signals in the input wiring. A low-pass filter is therefore used ahead of the delay-line to remove any high frequency signals.

TIME DELAY

A CCD (charge-coupled device) Delay-Line is used, and this operates by sampling the input at regular intervals and feeding the sampled voltages along a chain of capacitors. Eventually the signal reaches the end of the chain and the output of the delay-line.

The time it takes to go through the system, and the delay obtained, depends on the number of stages and the clock frequency. The device used in this design has 512 stages, and can produce delays of several milliseconds, but in this case a delay of only around half a millisecond is adequate, and a high clock frequency is therefore used.

As with any sampling system, the output from the delay-line is stepped, and it is effectively modulated with the clock signal. Another low-pass filter at the output filters out the clock signal to give a normal audio output signal. Like the low-pass filter at the input of the delay-line, it does not produce significant losses at audio frequencies.

ON HOLD

The next stage in the main signal path is a Hold Circuit, which provides the signal blanking. It would be easy to design a scratch blanker that put in a larger noise pulse than the one it removed. To work well a blanking circuit must smooth over the gap in the signal in such a way that the gap is as unobtrusive as possible.

The hold circuit is normally fed with a high control voltage, and it then acts as a simple buffer stage. When a “click” is detected, a negative pulse is applied to the control input, and the output voltage is then held at its current level until the control pulse ends. The hold circuit then acts as a simple buffer stage again, and a normal output signal is produced.

Ideally the blanking period would last for exactly one cycle, as in the top waveform of Fig.2. This avoids any sudden change in level at the end of the blanking period, and should avoid any audible glitch.

In practice things will not usually be quite as convenient as this, and there will be some jump in level, as in the middle waveform of Fig.2. Under worse case conditions there could be a much larger jump, as in the bottom waveform of Fig.2. The equalization attenuates the high frequencies generated by any sudden changes in the signal level and keeps the switching glitches as unobtrusive as possible.

The oscillograph of Fig.3 shows the effect of the blanking process. The scratch pulses should be in the initial part of the trace. Instead, the signal has been blanked and this part of the trace is flat.

Depending on the circuit values used, the unit can also blank the signal by holding the signal at the central bias level during the blanking period. Again this ensures that there are no major glitches introduced by the blanking process itself.

Returning to Fig.1, the final stage in the main signal path is the Equalization Amplifier stage. As pointed out previously, by having this stage at the output of the unit it effectively gives noise reduction over the entire circuit, including the delay-line.

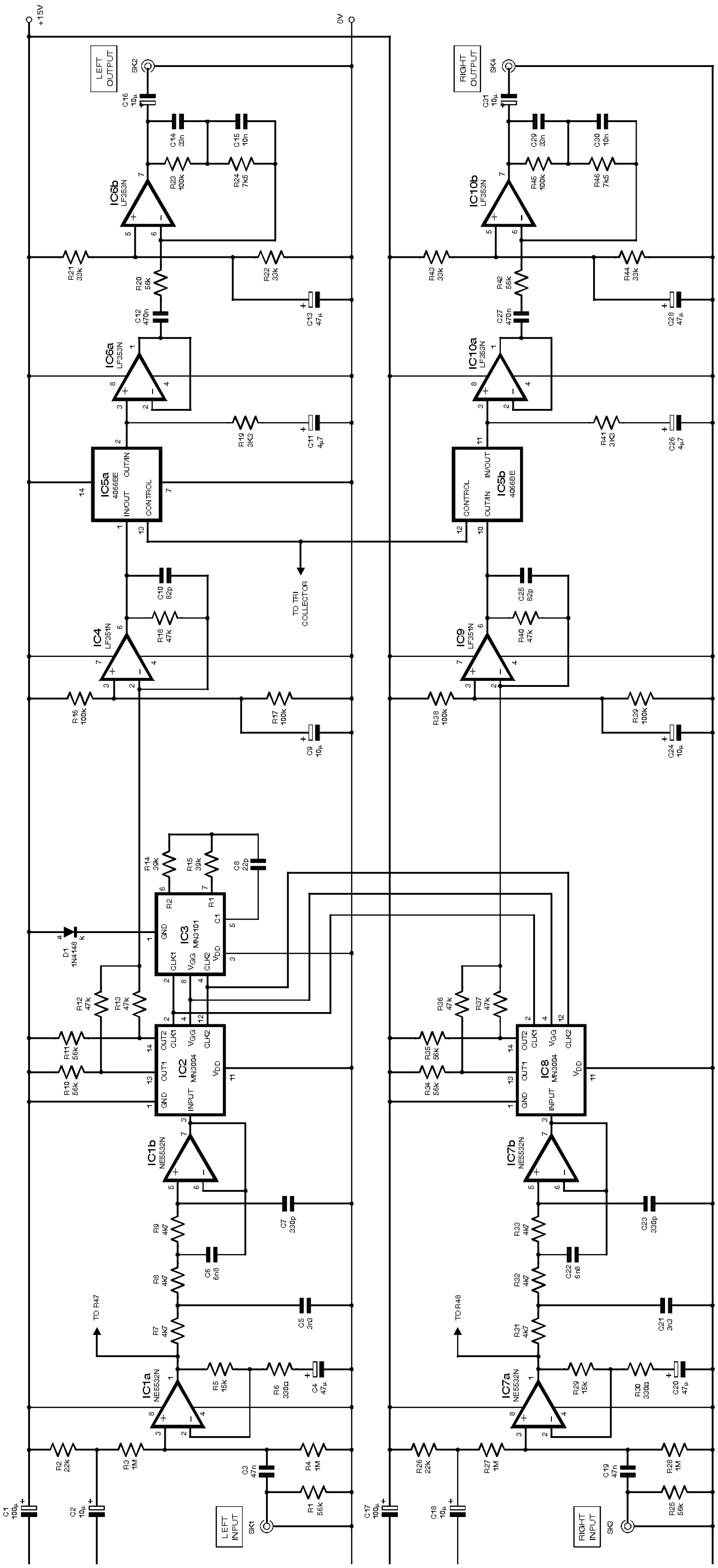


Fig.4. Main circuit diagram for the Scratch Blanker.

CLICK DETECTION

In order to provide the desired blanking action the circuit must provide suitable control pulses to the hold circuits. The ease or difficulty with which this can be done is entirely dependent on the program material.

With something like a recording of piano music where the general modulation level is quite low, any serious scratches should "stick out like a sore thumb". Things are much more difficult with a recording of pop music at high modulation levels and masses of high frequency "crashes" and "bangs".

Reliably blanking scratches on a recording of this latter type while leaving the main signal intact might not be possible. Fortunately, signals that make scratch detection difficult also tend to mask the "clicks" and "pops" from the human ear. It is in situations where the clicks are most noticeable that a blanker can most easily detect and remove them.

The outputs of the two preamplifiers are fed to a Differential Amplifier. The main signal is generally in-phase in the two stereo channels (to produce the center of the sound stage), or signals only appear in one channel or the other (to produce the sides of the sound stage). By contrast, the noise pulses produced by scratches tend to produce anti-phase signals. Combining the signals from the two stereo channels using a differential amplifier therefore adds together the anti-phase scratch signals, but to some extent cancels out the main signal.

The next stage is a high-pass filter. The scratch signals are predominantly at upper

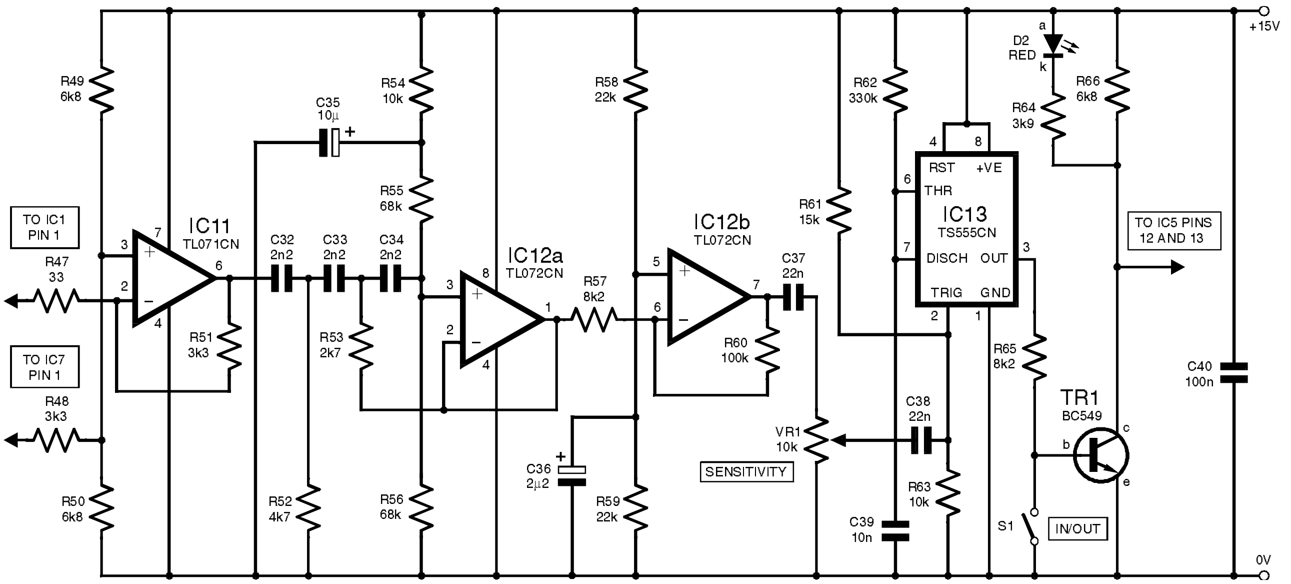


Fig.5. Circuit diagram for the "click" detector stages of the Scratch Blanker.

middle and high frequencies, and the high-pass filtering provides further attenuation of the main signal in relation to the scratch signals.

TRIGGER LEVEL

Next the signal is amplified to a level that enables it to trigger a monostable. A Sensitivity control enables the trigger level to be set high enough to give reliable triggering of the monostable, but low enough to prevent large parts of the main signal from being obliterated. The monostable produces an output pulse of about 3·5 milliseconds in duration, which should be sufficient to blank any scratch.

The hold circuits require low output pulses, but the output of the monostable is normally low and pulses high. An Inverter stage is therefore used to process the output of the monostable and produce a suitable control signal for the hold circuits. A LED indicator is also driven from the inverter stage, and this flashes each time the unit is triggered.

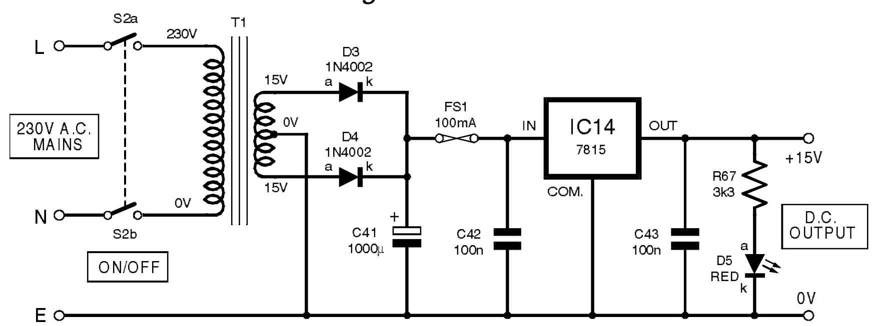


Fig.6. Scratch Blanker power supply circuit diagram.

CIRCUIT OPERATION

The main circuit diagram for the *Scratch Blanker*, showing the signal processing stages, appears in Fig.4. The circuits for the "click" detection and mains power supply unit appear separately in Fig.5 and Fig.6.

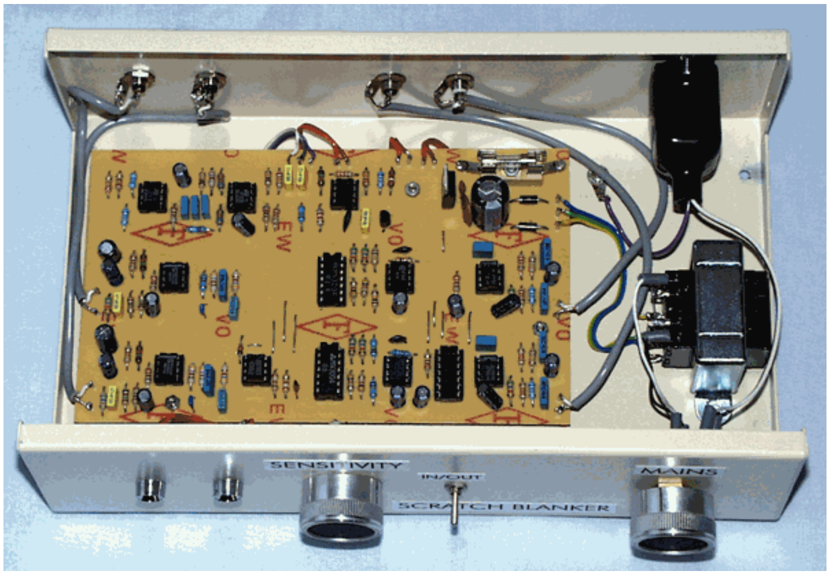
Starting with circuit Fig.4 and the left-hand channel (the right channel is identical), the input stage uses operational amplifier IC1 as a non-inverting circuit having its closed-loop voltage gain set at 45 by resistors R5 and R6. The input impedance is set at about 50k (kilohms) by resistor R1, which is the optimum figure for most magnetic cartridges. Increase the value of R1 and R25 to 120k for types that require a load impedance of 100k.

The low-pass filter ahead of the delay-line is a conventional three stage (18dB per octave) type based on IC1b. Its cut-off frequency is at approximately 20kHz.

DELAY-LINE

The charge-coupled delay-line IC2, is a MN3004 512-stage device. In common with other CCD delay-line chips it makes available the outputs of the last two stages. The point of this is that it is not possible for a stage to simultaneously receive a fresh sample and provide an output at the previous sample voltage.

A simple solution to this problem is to mix the output



signals from the last two stages. One or other of the stages will always have its output switched on and will supply a valid sample voltage.

Resistors R10 and R11 are load resistors for the last two stages of the delay-line, with R12 and R13 acting with IC4 as a conventional summing mode mixer to combine the two output signals.

Capacitor C10 provides a 6dB per octave roll-off above the audio range and provides the initial low-pass filtering to remove the stepping on the output signal. The equalization amplifier provides most of this filtering though.

CLOCKING ON

The delay-line requires a two-phase clock signal and a bias voltage, both of which are provided by matching support chip IC3. Most components are duplicated in the right-hand channel, but this stage provides the clock and bias signals for *both* channels.

The clock frequency is about 300kHz, which gives a delay of just under one millisecond. This gives more than enough time for the “click” detector to activate the hold circuit. The latter uses one of the four analog switches in a CMOS 4016BE or 4066BE (IC5a). The 4016BE is the device normally recommended for audio applications, but several samples of the 4066BE were tried in this circuit and worked equally well. One of the other switches in IC5 (d) is used in the right-hand channel, but the other two are left unused.

With the specified values for resistor R19 and capacitor C11 the hold circuit produces an output at a central bias level during the blanking periods. Using values of 330 ohms and 10 nanofarads provides a true hold action, with the final signal voltage being held until the end of the blanking period. Results seem to sound much the same either way. IC6a is the buffer amplifier for the hold circuit.

EQUAL MEASURE

The other section of IC6 (b) is used in the equalization amplifier. Normally a stage of this type would be required to produce large amounts of amplification at middle and low audio frequencies.

This is not the case here, because the input stage provides most of the amplification, and only a modest amount of gain is required from the equalization stage. In fact, a degree of attenuation is required at high frequencies.

This stage is, therefore, based on an inverting mode circuit rather than the more usual non-inverting type, and the value of resistor R20 has been made quite high so that the voltage gain is kept in check. With some power amplifiers and cartridges the output level might be inadequate. Reducing the value of resistors R20 and R42 to about 10k (kilohms) will increase the gain of the equalization circuit and cure this problem.

The circuit has only a limited amount of “headroom'”, so this modification should only be made if it is really necessary. Otherwise at high volume levels the signal may be clipped.

CLICK DETECTOR

In the Click Detector circuit (see Fig.5) opamp IC11 is used as a conventional differential amplifier at the input. An active three-stage (18dB per octave) high-pass filter based on IC12a follows this. The filtered output signal from IC12a is amplified by IC12b, which operates as an inverting amplifier having a voltage gain of about 12. The boosted signal from IC12b is fed, via capacitor C37, to Sensitivity control VR1, and this is connected as a volume control style variable attenuator.

The monostable stage has low power timer IC13 connected as a standard 555 monostable. It is not advisable to use an

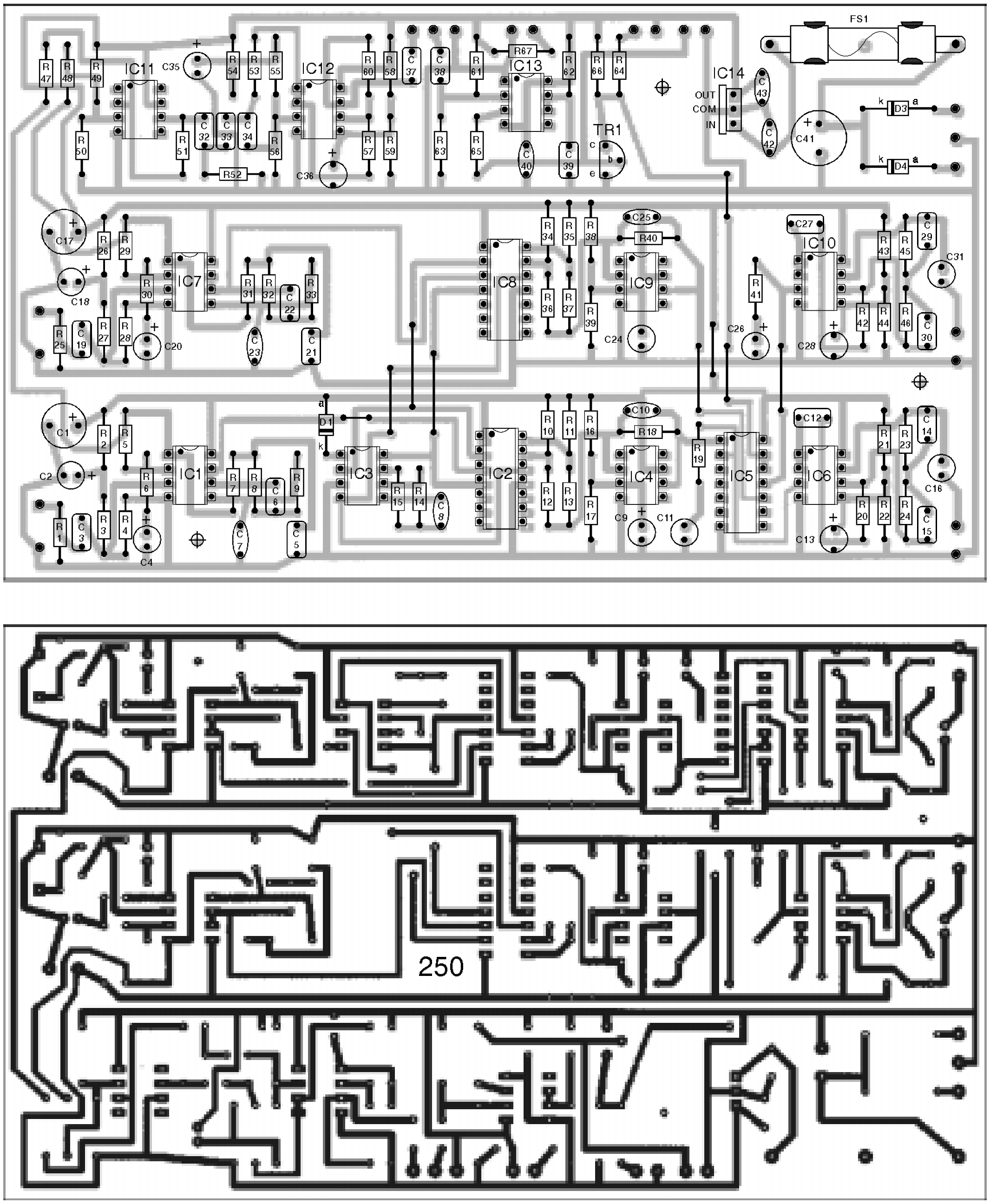


Fig.7. PCB topside component layout and (approximately) full size underside copper foil master for the Scratch Blanker. The interwiring between the PCB and off-board components is shown in Fig.8.

ordinary 555 timer for IC13 as the standard 555 chip tends to "crowbar" the power supply on output transitions. This would tend to introduce noise spikes into the signal paths, reducing the effectiveness of the unit. Low power 555 timers such as the TS555CN are free from this defect.

Resistor R62 and capacitor C39 are the timing components and they set the nominal output pulse duration at 3·63 milliseconds. The trigger input at pin 2 of IC13 must be taken below one third of the supply potential in order to trigger the circuit. Under quiescent conditions, resistors R61 and R63 bias pin 2 just above this level, but strong negative half cycles from control VR1 will take the input below the threshold voltage and trigger the monostable.

Transistor TR1 is a simple common emitter switching stage

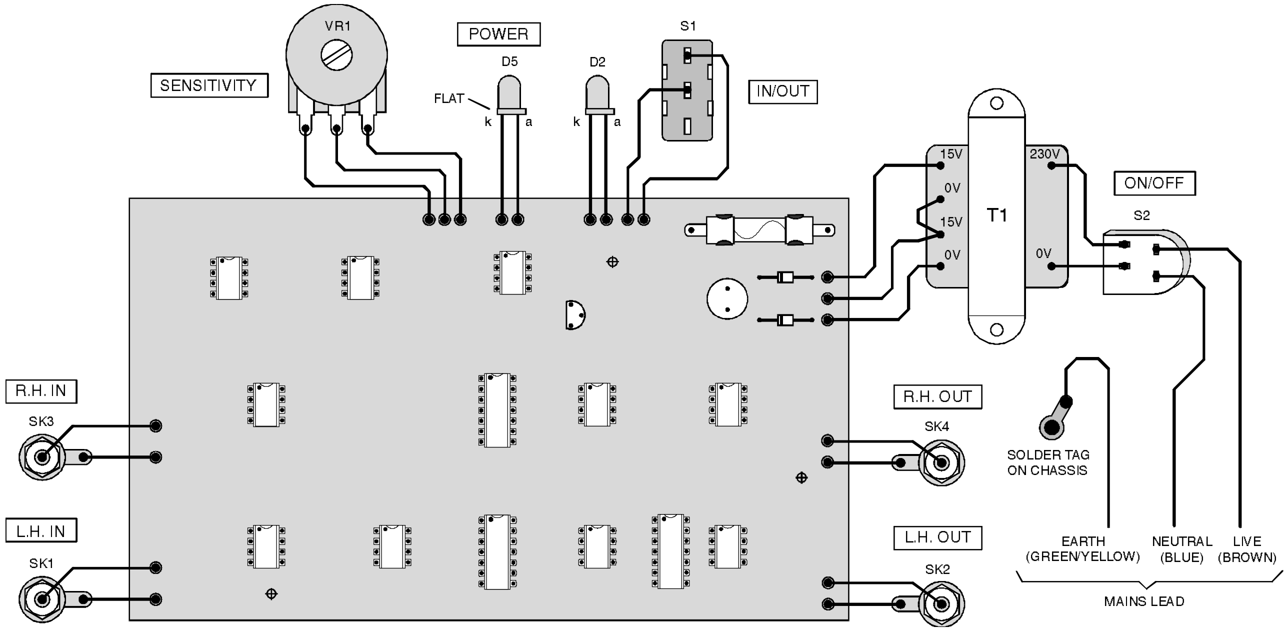


Fig.8. Interwiring details from the PCB to off-board components. Note you must use screened leads from the PCB to the input and output sockets (SK1-SK4).

that inverts the output signal from IC13 and also drives LED indicator D2. This LED will flash briefly each time the unit is triggered.

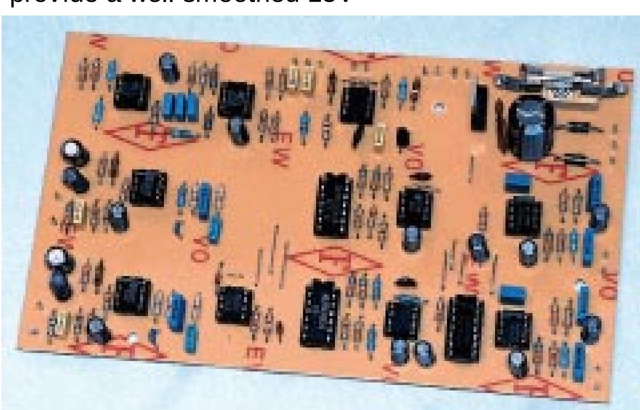
Switch S1 provides in/out switching. The unit functions normally when S1 is open, but closing this switch holds TR1 in the off state, and inhibits the blanking action.

POWER SUPPLY

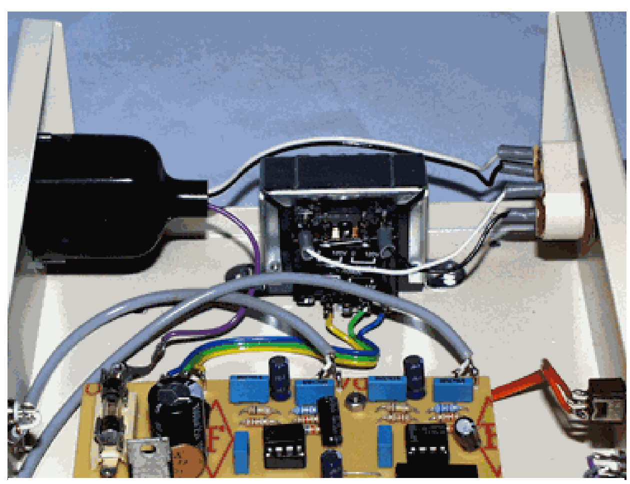
The power supply must provide a well smoothed 15V supply at a maximum current of no more than about 60mA or so. A suggested mains driven Power Supply circuit diagram is given in Fig.6. **(Note that this power supply is designed for use with a 240V 50Hz mains supply. If your mains supply is different you will need to modify this circuit accordingly, in which case it is recommended that you consult a qualified electrician).**

Mains transformer T1 provides isolation from the mains and the required voltage step-down. Rectifier diodes D3 and D4 provide full-wave rectification and capacitor C41 the smoothing. The unregulated supply is fed, via fuse FS1, to a 15V monolithic voltage regulator (IC14) that produces a well-stabilized output and also contributes further smoothing.

A 78L15 (100mA) regulator



Completed circuit board ready for mounting inside the metal case.



Prototype model showing, in close up, positioning and wiring to the mains transformer.

COMPONENTS

Resistors
R1, R10, R11, R20, R25, R34, R35, R42 56k (8 off)
R2, R26, R58, R59 22k (4 off)
R3, R4, R27, R28 1M (4 off)
R5, R29, R61 15k (3 off)
R6, R30 330 ohms (2 off)
R7, R8, R9, R31, R32, R33, R52 4k7 (7 off)
R12, R13, R18, R36, R37, R40 47k (6 off)
R14, R15 39k (2 off)
R16, R17, R23, R38, R39, R45, R60 100k (7 off)
R19, R41, R47, R48, R51, R67 3k3 (6 off)
R21, R22, R43, R44 33k (4 off)
R24, R46 7k5 (2 off)
R49, R50, R66 6k8 (3 off)
R53 2k7
R54, R63 10k (2 off)
R55, R56 68k (2 off)
R57, R65 8k2 (2 off)
R62 330k
R64 3k9
All 0.25W 5% carbon film

Potentiometer
VR1 10k carbon rotary linear

See also the SHOP TALK Page!

Capacitors
C1, C17 100u radial electrolytic, 16V (2 off)
C2, C9, C16, C18, C24 10u radial electrolytic, 25V (7 off)
C3, C19 47n polyester (2 off)
C4, C13, C20, C28 47u radial electrolytic, 25V (4 off)
C5, C21 3n3 polyester (2 off)
C6, C22 6n8 polyester (2 off)
C7, C23 330p ceramic plate (2 off)
C8 22p ceramic plate
C10, C25 82p ceramic plate (2 off)
C11, C26 4u7 radial electrolytic, 50V (2 off)
C12, C27 470n polyester (2 off)
C14, C29 33n polyester (2 off)
C15, C30, C39 10n polyester (3 off)
C32 to C34 2n2 polyester (3 off)
C36 2u2 radial electrolytic, 50V
C37, C38 22n polyester (2 off)
C40, C42, C43 100n ceramic (3 off)
C41 1000u radial electrolytic, 25V

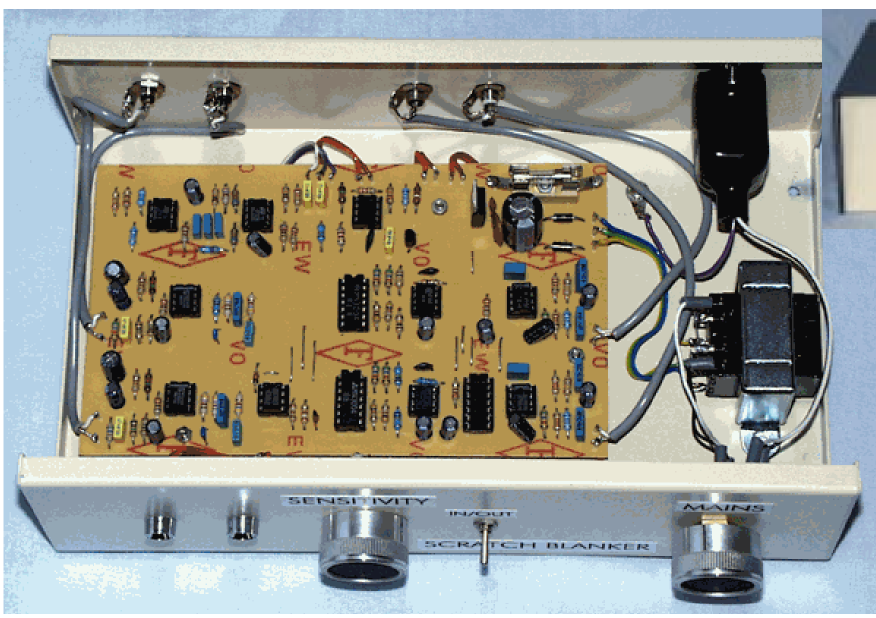
Semiconductors
D1 1N4148 silicon signal diode
D2, D5 5mm red panel LED (2 off)
D3, D4 1N4002 100V 1A rectifier diodes (2 off)
TR1 BC549 silicon *npn* transistor
IC1, IC7 NE5532N dual opamp (2 off)

Semiconductors (cont.)
IC2, IC8 MN3004 512-stage delay-line (2 off)
IC3 MN3101 clock generator
IC4, IC9 LF351N bi-FET opamp (2 off)
IC5 4066BE or 4016BE quad CMOS switch
IC6, IC10 LF353N dual bi-FET opamp (2 off)
IC11 TL071CN bi-FET opamp
IC12 TL072CN dual bi-FET opamp
IC13 TS555CN low-power timer
IC14 7815 15V 1A positive regulator

Miscellaneous
S1 s.p.s.t. miniature toggle
S2 rotary mains dual-pole on/off switch
SK1 to SK4 chassis-mounting phono sockets (4 off)
FS1 100mA 20mm quickblow fuse
T1 standard mains transformer, with 15V-0V-15V 100mA secondary

Printed circuit board available from the *EPE Online Store*, code 7000250 (**www.epemag.com**); medium to large instrument case, see text; 8-pin DIL socket (10 off); 14-pin DIL socket (3 off); 20mm chassis-mounting fuse holder; control knob (2 off); mains lead and plug; screened cable; connecting wire; solder pins, solder, etc.

Approx. Cost Guidance Only (Excluding case and mains lead/plug) **$86**



Front panel arrangement of the completed Scratch Blanker.

Layout of components inside the case of the finished Scratch Blanker. Note the PCB and mains transformer should be kept as far apart as possible.

can handle the currents involved here, but might overheat due to the power levels involved. Hence, a 7815 (1A) regulator is specified for IC14. Diode D5 is the power indicator LED, and R67 is its current limiter resistor.

CONSTRUCTION

As this project is mains powered and is fairly complex it is not really suitable for *beginners*. The use of a custom printed circuit board (PCB) does, however, help to keep things reasonably straightforward.

The component overlay for the circuit board appears in Fig.7, together with the (approximately) full size copper foil master pattern. This board is available from the *EPE Online Store* (code 7000250) at **www.epemag.com**

The only static-sensitive components are IC2, IC3, IC5, and IC8, and the normal handling precautions should be observed when dealing with these devices. It is advisable to use holders for all the other DIL integrated circuits as well. Voltage regulator IC14 might become quite warm in use, but it should not be necessary to fit it with a heatsink.

Construction of the board largely follows conventional lines. A few link-wires (9 off) are required, and these are made from 22s.w.g. or 24s.w.g. tinned copper wire. They are reasonably well spaced out so it is not essential to insulate them with pieces of sleeving.

The capacitors must be miniature PCB mounting types in order to fit into this layout properly. The polyester capacitors should have a lead spacing of 5mm (0·2 inches).

Fuse FS1 fits into an ordinary 20mm chassis mounting fuseholder that is bolted to the circuit board. The board is connected to the tags of the fuseholder by way of two solder pins fitted on the board. With the tags of the holder in an almost horizontal position it should be quite easy to solder them to the pins.

CASING UP

Readymade hi-fi style cases are “a bit thin on the ground” these days, so it is a choice between the do-it-yourself approach and settling for an instrument case. Either way the case must be about 250mm wide and 150mm deep in order to accommodate everything comfortably.

As this project is mains powered it must have a case that is made from METAL, and the case must be reliably EARTHED to the mains’ Earth lead. It is also essential to use a case that has a screw fitting lid, and not a clip-on type that would permit easy access to the dangerous mains wiring. The mains lead can be wired direct to the unit, but the safer option is to mount an IEC mains inlet on the rear panel of the case and use a standard IEC mains lead.

The circuit board is mounted on the left-hand section of the base panel using 6BA or metric M3 screws (see photographs), plus the usual spacers to keep the underside of the board clear of the metal case. Mains transformer T1 is mounted on the extreme right-hand section of the base panel so that it is as far away from the circuit board as possible.

The input and output connectors are phono sockets, and they are mounted on the rear panel of the case. The controls and the two LEDs are mounted on the front panel, the exact layout is not too important.

However, On/Off switch S2 should be positioned well towards the right-hand end of the panel close to T1, with the other controls reasonably well separated from it. A solder tag bolted to the base panel provides a connection point for the mains Earth lead.

INTERWIRING

Details of the hard wiring to the PCB and off-board components are provided in Fig.7 and Fig.8. This is largely straightforward, but as some of the wiring carries the mains supply it is *essential* to take extra care and to double-check the entire wiring once it has been completed. The input wiring is very sensitive to stray pick-up of mains “hum”, and screened cable *MUST*, therefore, be used for the connections from phono sockets SK1 and SK3 to the circuit board.

Indicator LEDs D2 and D5 will not work properly unless they are connected the right way round. The polarity of LEDs is normally indicated by the cathode (k) lead being shorter than the anode (a) lead. It is advisable to use high brightness LEDs, particularly for D2, which receives only very brief pulses of current.

A mains transformer having a 15V-0V-15V secondary winding is required for T1, but modern mains transformers almost invariably have twin secondary windings. These can effectively produce the required type of secondary winding if they are connected in the

manner shown in Fig.8.

Note that some mains transformers also have twin primary windings. For use on the 230V UK mains supply the two primary windings must be connected in *series*. **Use pieces of sleeving to insulate any connections that carry the mains supply.**

TESTING

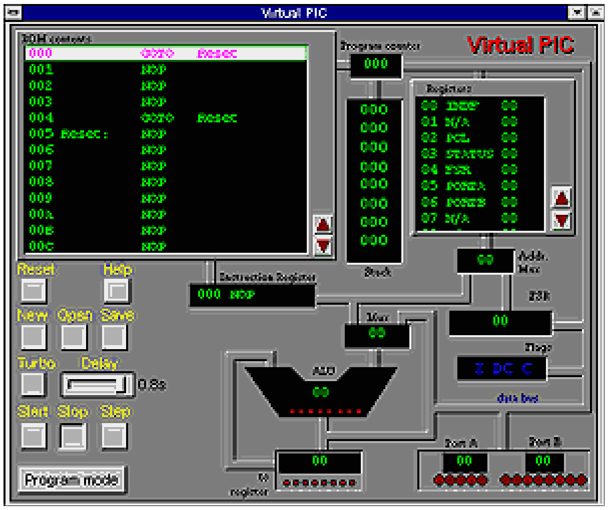
In use the record deck connects to input sockets SK1 and SK3, and the output sockets (SK2 and SK4) connect to the power amplifier using normal screened phono leads. The record deck will probably have an earth lead, and results will probably be best with this connected to the earth terminal of the power amplifier. If this gives problems with "hum" loops try adding a suitable connector to the case of the *Scratch Blanker* so that the deck can be earthed here instead.

Using a suitably "click" infested test recording, it should soon be obvious whether or not the unit is functioning. With Sensitivity control VR1 fully advanced in a clockwise direction the "clicks" should be blanked, but it is likely that sections of the recording at high modulation levels will also be removed.

Control VR1 should be adjusted for the highest sensitivity that does not result in significant blanking of the wanted signal. Since modulation levels vary slightly from one record to another, the optimum setting for VR1 will also be slightly different for each record.

Go to next section

Interested in programming PIC microcontrollers? Learn with *PICtutor* by John Becker



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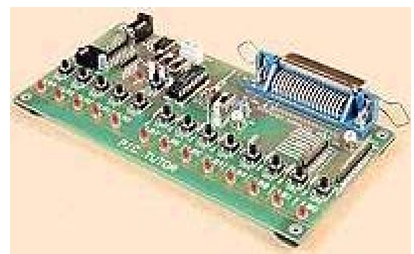

Deluxe PICtutor Hardware

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Low Cost AA to PP3 Converter – Service Call

There are a variety of integrated devices available which perform single cell DC conversion. However, for some applications these may be limited in output voltage or be relatively expensive. The circuit diagrams shown in Fig.1 perform the same service for a very low cost and at a reasonable efficiency.

The simplest, Fig.1a is suited to applications that present a constant load. Transistor TR1, transformer T1, resistor R1, and preset potentiometer VR1 form a current-controlled switching oscillator. Each time TR1 turns off the collapsing magnetic field in T1 generates a high voltage positive pulse at TR1's collector. This, in series with the supply, is fed via diode D1 to capacitor C2. Under no-load it contains 30V. At constant load it remains stable and can be adjusted with preset VR1, but as loading increases it drops.

In applications exhibiting variable loading, regulation is necessary. The circuit shown in Fig.1b uses a pulse skipping technique i.e., occasionally inhibiting oscillation to maintain constant output. Transistors TR1 and TR2 form a simple Schmitt trigger comparator. Although both collector loads are identical, a switching differential is maintained because TR2 is directly coupled to TR1; its base current contributes to the voltage across resistor R3.

The Schmitt threshold consists of TR1 VBE and the voltage across resistor R3. As the monitored voltage rises above this, TR1 turns on, TR2 turns off and TR3 turns on which disables transistor TR4. When it drops the reverse occurs. Hysteresis ensures clean switching and preset VR1 adjusts the output voltage. Diode D1 prevents negative pulses being routed via transistor TR3 and affecting the Schmitt trigger; it must be a Schottky diode otherwise TR3 will not switch TR4. The recommended ZTX650 transistor used for the oscillator is a high performance device with a very low VCE(SAT). This is necessary because there is little headroom at 1·0V.

As switching occurs at a very high frequency, T1 is extremely small. A micro-toroid center tapped transformer is constructed using an anti-parasitic bead 6mm by 4mm in diameter with a 2mm hole. Fold 90cm of 38s.w.g. enameled copper wire in half, press the crease tightly together and then thread the folded wire repeatedly through the bead hole until 20 turns are wound. Trim pro-

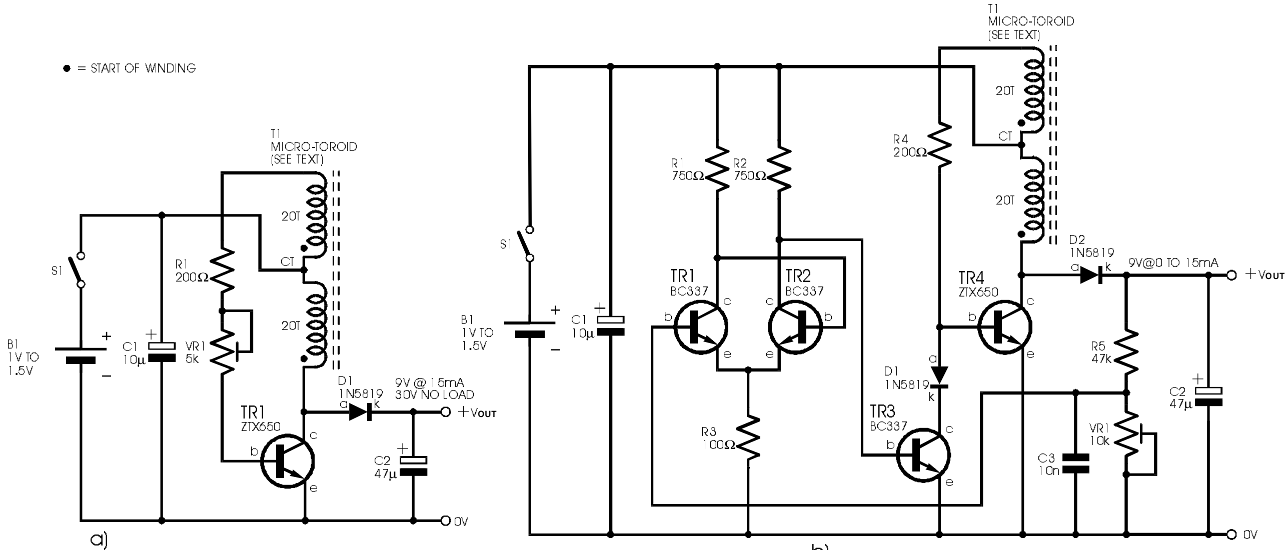


Fig.1. Low Cost AA to PP3 Converter. (a) Simple converter and (b) pulse skipping regulated version.

truding wires to 25mm.

The bead now contains two sets of 20 turns with two starts at one extremity and two ends at the other. Join an appropriate start and end together to form the tap (ct). If the circuit fails to oscillate, check the tap is correctly formed; otherwise, it is most likely a shorted turn.

Using a NiCad or NiMH battery with its virtually flat discharge characteristic will minimize supply drift.

Z. Kaparnik
Swindon, Wilts, UK

Electric Garage Door Status Indicator – An Open or Shut Case

My electric garage door can be operated using an RF remote control or with an illuminated pushbutton near the garage back door. The existing pushbutton is wired to the lifter's control terminals which supplies a limited current at approximately 17V DC to power the pushbutton LED. Shorting the terminals or drawing a large current triggers the unit into lifting or closing the door.

The circuit shown in Fig.2 was added so that the state of the door – open or closed – could be determined without going outside to look at it. An extra switch, S2, and bicolour LED D3 were fitted so that the door could be operated from inside the house if ever the remote

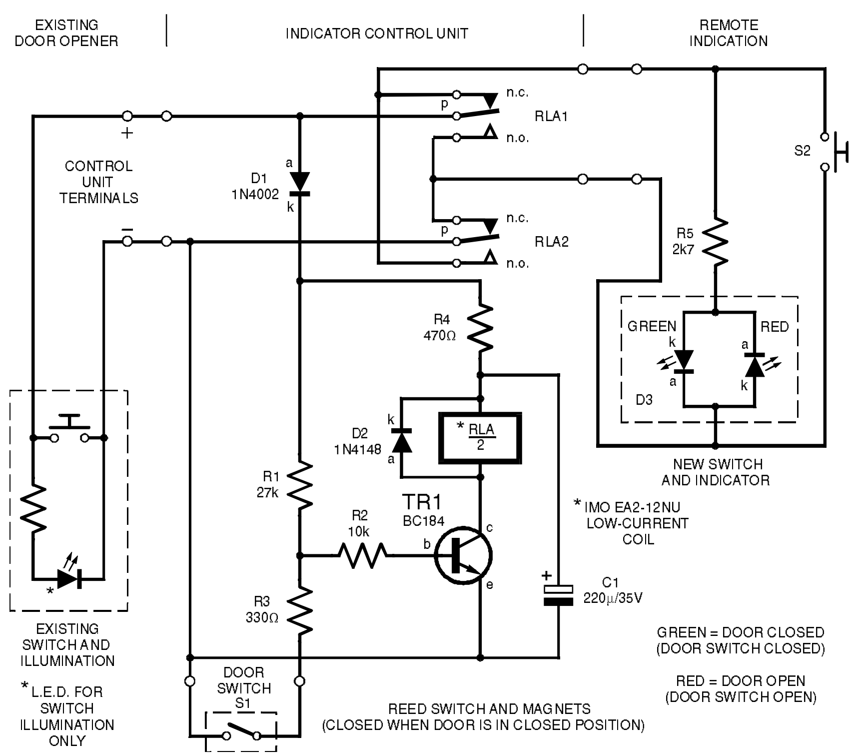


Fig.2. Circuit diagram for the Electric Garage Door Status Indicator.

control was mislaid.

The extra switch S2 and dual color LED D3 are placed in parallel with the existing operating switch. The supply to D3 is reversed when the relay RLA is on, turning the green LED (closed) off and the red LED (open) on.

A standard alarm reed proximity switch, S1, is mounted on the garage door frame with the accompanying magnet fitted to the door. When the door is closed the reed switch is closed which turns transistor TR1 and the relay off by shunting the base (b) current to 0V. When the door is open, TR1 drives the relay, which changes the indicator LED.

To minimize the current drain from the door control unit and prevent the door inadvertently opening or closing, it is important that the relay has a low current coil. An IMO/ Omron EA2-12NU was used, whose coil is fed via resistor R4 and capacitor C1 to reduce the holding current as follows:

When the relay is off C1 charges up to the supply voltage, approximately 17V and acts as a reservoir. When TR1 turns on, the capacitor supplies most of the pull-in current required by the relay to operate it.

When capacitor C1 has discharged, the resistor R4 provides a much lower holding current for the relay to reduce the current consumption. Diode D1 provides reverse polarity protection and resistors R2 and R3 provide some protection for TR1 against short circuits to the supply connections. All the usual precautions should be observed when operating electric garage doors, making sure vehicles, children and others are kept well clear.

Keith Wevill
Ratby, Leics, UK

Go to next section

VEHICLE FROST BOX by STEVE DELLOW

Black ice on the road can be a killer. This design helps predict when it might occur.

Vehicle manufacturers strive to make our driving experience ever more comfortable. Such items as ride control, power steering, electronic engine management, and air-conditioning now appear as standard fit on many vehicles. As a result we become more and more detached from the outside environment.

One of the most important considerations would seem to be the quality of the contact between tires and road surface, a factor that directly affects our style of driving. We generally notice if the road is wet, muddy or covered in leaves and take appropriate precautions, but we can't see black ice. For this we need an external temperature sensor, warning us when the likely conditions for ice on the road are developing.

A cheap solution is the liquid crystal strip attached to the driver's wing mirror, but despite looking very pretty (especially if you have heated mirrors . . .), it tells us nothing about conditions

down at road level. The *Vehicle Frost Box* gets us right there!

DESIGN BASIS

The *Vehicle Frost Box* is powered from the vehicle ignition supply, and uses a remote temperature sensor that can be mounted close to the road surface. The display is a single tri-color light emitting diode (LED) element mounted within the driver's compartment, and some simple circuitry drives it in three modes to indicate the variation of external temperature.

Above 4°C, the LED shows a steady green, indicating that the likelihood of ice is low, and reassures us that the *Frost Box* is operational. As soon as the sensor detects the temperature dropping below the 4°C threshold, the LED turns a steady red, warning that things are deteriorating outside – time to start driving with black ice in mind!

Finally, when the temperature falls below freezing (0°C), the LED flashes alternately red and green to indicate that maximum care should be taken.

OPTIONS

There are a number of temperature sensing methods available to us – thermistors, thermometers, and thermocouples to mention but a few – all are used in environment monitoring, but most are outside the budget (or practicality) of the average home constructor. We are therefore looking for an approach that's cheap, reliable, linear, and has low thermal mass, thereby allowing a quick response to variation in air temperature.

The chosen technique here is to make use of the physical characteristics of a silicon semiconductor junction, in the shape of a diode. The voltage drop across these devices when forward biased is related to a number of factors, but the two we are interested in (and have control over) are current and temperature.

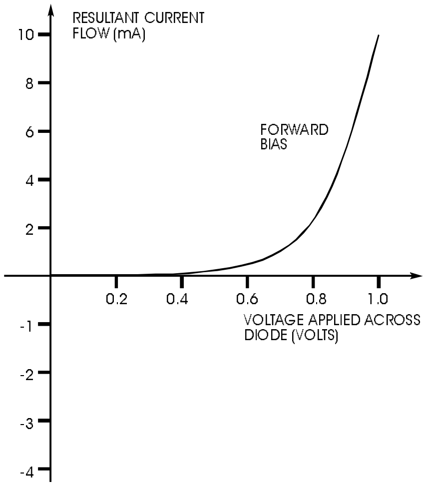


Fig.1. Voltage/current (V/I) characteristics of a forward biased silicon diode.

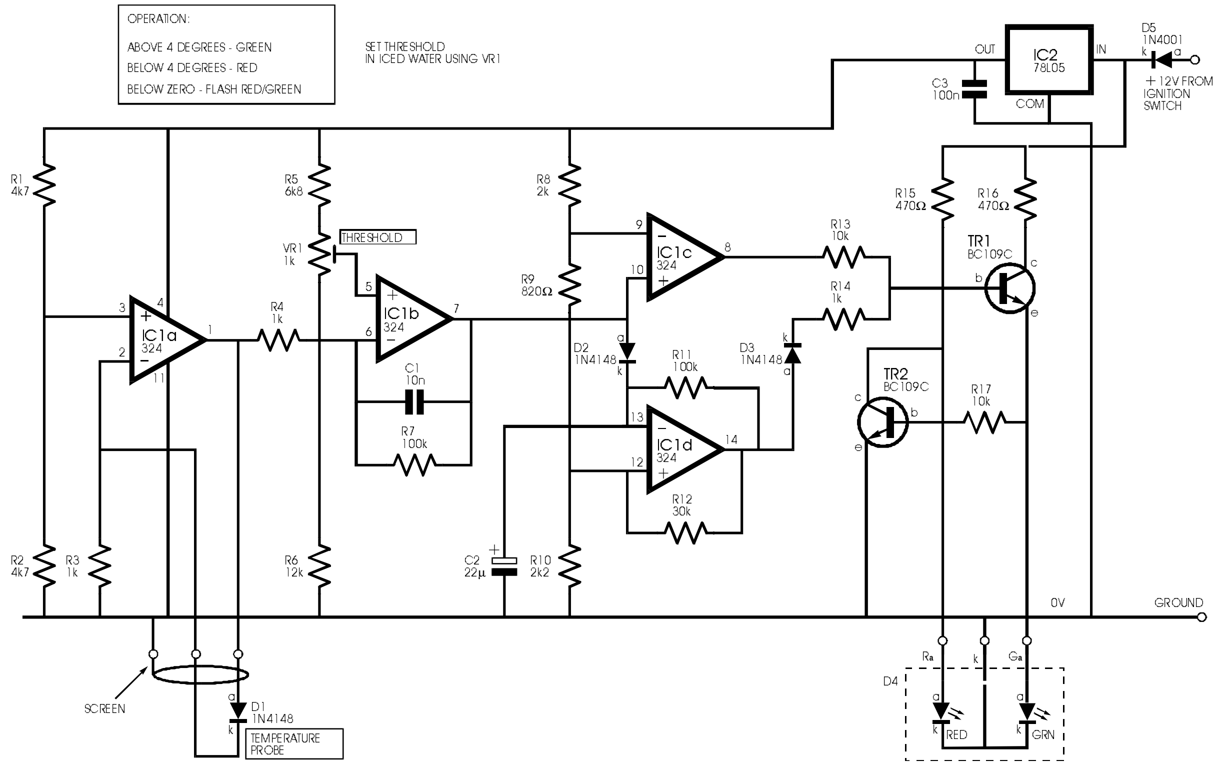


Fig.2. Complete circuit diagram for the Vehicle Frost Box.

COOL GRAPH

The graph in Fig.1 shows the voltage/current (V/I) characteristics for a silicon diode and we can see that the forward voltage varies in a distinctly non-linear fashion in relation to current – not desirable for our measuring device.

However, if we can keep the current through the diode constant, we can make use of the other variable that affects the forward voltage – temperature – and under constant current conditions, the forward voltage drop across a silicon junction falls by 2·5mV for every 1°C rise. We therefore have a sensor that suits our requirements, especially if we use a small signal diode such as the 1N4148 – exceedingly cheap and very cheerful.

CIRCUIT DESCRIPTION

The *Frost Box* is based around a type 324 integrated circuit, which contains four opamp blocks. The complete circuit diagram is illustrated in Fig.2.

Each opamp block is used in a different way to process the sensor signal. The first, IC1a, creates a constant current through the sensor diode, D1. IC1b amplifies the diode voltage variations. IC1c is used as a comparator and IC1d is configured as an oscillator.

To create the constant current, a fixed voltage is applied to the non-inverting input of IC1a, this being set at half supply level by resistors R1 and R2. With the sensor diode in the feedback loop to the inverting input, and with R3 connected to ground, the voltage output of the opamp moves in the appropriate direction towards supply or ground to make both inputs become equal.

In other words, it tries to make the voltage at the top of R3 the same as that at the junction of R1 and R2. If it achieves this, then the voltage at the top of R3 is always the same (about 2·5V) and the current through the diode will always be constant (about 2·5mA) even when the voltage across the diode is varying with temperature. The outcome of all this is that the voltage at the output of IC1a is directly related to the temperature of the diode – a good start!

AMPLIFICATION

Although we now have a voltage related to temperature, the variations are very small and they need amplifying for us to be able to make any use of them. The second opamp, IC1b, is configured as a voltage amplifier, and to make things

simpler in the later stages, the inverting mode is used so that we create a voltage that rises with temperature.

The amplification factor is controlled by the ratio of resistors R7 and R4, and the values shown give a DC gain of –100 (100k/1k). This results in an output that varies by +0·25V/°C, which is much easier to work with.

To make sure that the amplified voltage is at a sensible level (i.e. nicely between the supply rails!), preset potentiometer VR1 is used to adjust the voltage at the non-inverting input. When setting up the unit this is used to calibrate the threshold for 0°C.

Finally, capacitor C1 reduces the AC gain of the stage at frequencies above about 100Hz to prevent any HF (high frequency) problems.

At the output of IC1b there is now a voltage that is of a sensible magnitude, and moving in the right direction. It just remains to process it to recognize the three temperature stages.

TEMPERATURE MEASUREMENT

Since the voltage output from IC1b is directly proportional to the temperature of the sensor, it can be compared to the desired thresholds at 0°C and 4°C by the use of a simple resistive ladder.

The third opamp, IC1c, is used to control the red/green LED (D4) switchover at 4°C. It is wired as a simple voltage comparator, i.e. when the input voltage at the non-inverting input (pin 9) is above the inverting input (pin 10), the

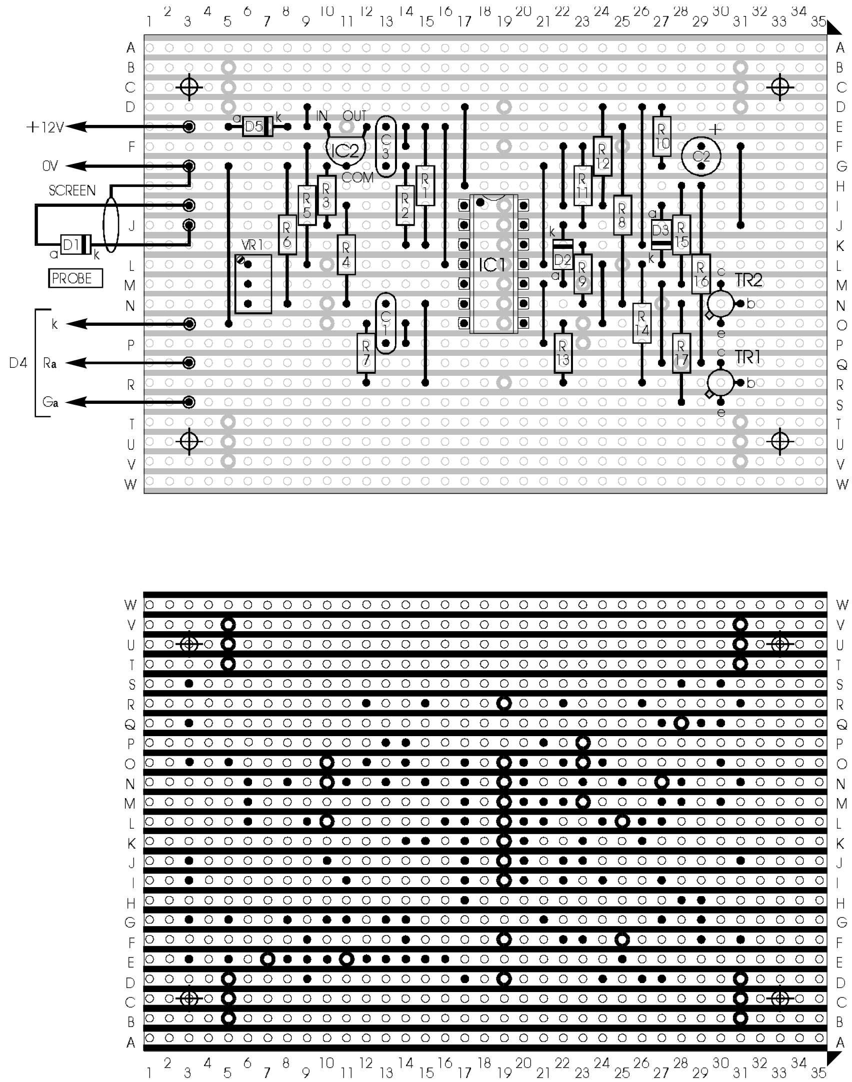
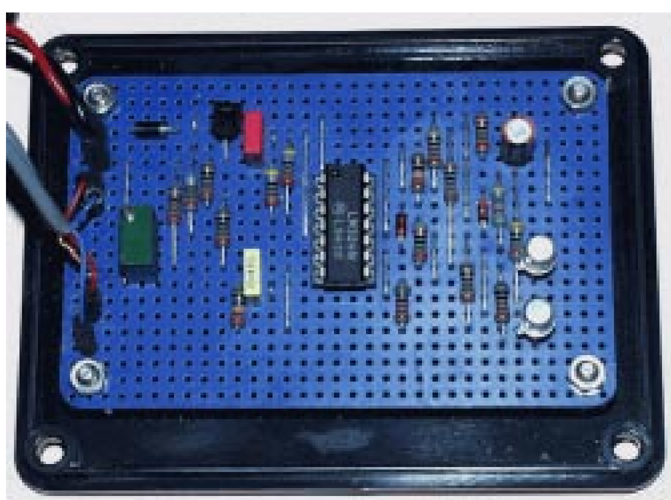


Fig.3. Component layout and track cuts on the stripboard assembly.



output is driven high (towards the +5V supply rail). This indicates that the temperature is above 4°C.

When the input voltage falls below that at pin 10, the output swings low (towards 0V), to indicate that the temperature is now below the upper temperature threshold.

FLASHING CLEVER!

Now for the clever bit! When the voltage falls further and reaches freezing point, we want to enable an oscillator that will flash the LED at a controlled rate. This is achieved by the components around the fourth op-amp, IC1d. Fundamentally, the comparator function is present again here, but used to much greater effect!

The oscillator function is created by setting a voltage threshold at the non-inverting input (pin 12) which varies when the output of the opamp changes state – this is basically referred to as a *Schmitt trigger* action.

The use of feedback related to the output state (high or low) controls the threshold at which the comparator switches. This configuration sees most use as an input circuit buffer to "clean-up" slowly varying signals and create a sharp switching point. By linking a C/R (capacitor/resistor) network to the inverting input (pin 13) the circuit can be made to oscillate in a controlled fashion.

When the output of this opamp is high, capacitor C2 will charge up through resistor R11, but when the output switches low, it starts to discharge along the same route.

Since the junction of R11 and C2 is connected to pin 13 of

COMPONENTS

Resistors
R1, R2 4k7 (2 off)
R3, R4, R14 1k (3 off)
R5 6k8
R6 12k
R7, R11 100k (2 off)
R8 2k
R9 820 ohms
R10 2k2
R12 30k
R13, R17 10k (2 off)
R15, R16 470 ohms (2 off)
All resistors 0.25W 5%, or better

Potentiometer
VR1 1k miniature preset, 15-turn, vertical adjustment

Capacitors
C1 10n ceramic, 0.2in spacing
C2 22u electrolytic radial, 16V
C3 100n ceramic, 0.2in spacing

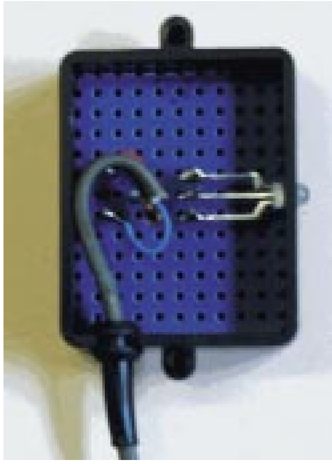
Semiconductors
D1 to D3 1N4148 signal diodes (3 off)
D4 tricolor LED, 3mm
D5 1N4001 rectifier diode
TR1, TR2 BC109C *npn* transistor
IC1 324 quad opamp
IC2 78L05 +5V 100mA regulator

Miscellaneous
Stripboard, 0.1in matrix, 35 holes x 23 strips; 14-pin DIL socket; PCB supporting pillars (4 off); screened cable, stereo, length to suit vehicle; cable ties; self-adhesive cable ties; electrical "bullet" connector (see text); plastic case to suit; terminal pins, 1mm; connecting wire, vehicle grade, for power supply, length to suit vehicle; heat-shrink sleeving, solder. etc.

See also the SHOP TALK Page!

Approx. Cost Guidance Only $19 (Excl. connectors/cables)

the opamp, the voltage on the capacitor will influence what state the output is in, and therefore whether it is charging or discharging. Consequently, current flows backwards and forwards through R11 as the output switches high and low. In other words we have an oscillator!



FLASH RATE

The oscillation frequency is related to the values of R11 and C2, and to the voltage at the non-inverting input (controlled mainly by R12). But how do we control when the oscillator is switched on? This is where diode D2 comes into play. The temperature-related voltage from pin 7 of IC1b is fed via this diode to the inverting input pin 13 of the oscillator opamp IC1c.

While the temperature is above freezing, the voltage through D2 keeps the output in a low state by preventing the input from falling below the threshold voltage at the non-inverting input. Basically, it stops the capacitor from discharging enough to flip the output state. As the temperature falls, there is a point where the voltage threshold is reached, and the inhibition is removed, allowing the circuit to oscillate away!

LED CONTROL

A tricolor LED is used to convey the temperature information to the driver. These devices have separate green and red junctions, and allow us to create all the warning signals we require within one discrete

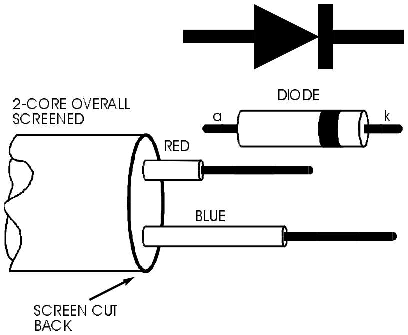


Fig.4. Temperature sensor diode wiring (before encapsulation).

package.

Above 4°C, the output from opamp IC1c is high (towards about 5V) and this provides base current to transistor TR1 via current limiting resistor R13, causing it to switch on.

Current now flows through the green element of the LED informing us that the circuit and outside temperature are healthy. The voltage drop across an illuminated LED is typically about 2V and this is used to turn on TR2 and inhibit the red element of the LED by shunting its current through the transistor.

When the temperature falls below 4°C, the output from IC1c switches low, and TR1 is switched off. The green LED element is therefore turned off and, with TR2 now also disabled, the red LED lights up, signaling that the temperature is falling.

Opamp IC1d has no effect at this point as its output is held low by the action of D2, but as soon as freezing point is reached, it bursts into oscillation!

When the oscillator's output is high, it overrides IC1c's control of TR1 and forces it to turn on the green LED. Then, when the output goes low the red LED comes back on, thus

giving us an LED that flashes alternately red and green. The current through the LED is controlled by resistors R15 and R16, and is set quite high (about 20mA) to give a good bright output.

POWER SUPPLY

Power for the circuit is taken from the vehicle ignition supply, and series diode D5 prevents any catastrophes if the supply is wired the wrong way round!

Since some constant voltage references are needed to keep the temperature measurements accurate, a 5V voltage regulator (IC2) is used to provide stability and isolate the circuit from variations in the vehicle supply. To prevent the switching currents from the LEDs affecting this stabilized voltage, their supply is taken before the regulator.

CONSTRUCTION

The component layout shown in Fig.3 is constructed on a piece of 0·1 inch stripboard, size 35 holes by 23 strips. These dimensions permit a tidy layout and allow room for some mounting holes. Having cut your board to the desired size, the track breaks should be made as indicated, either by using the appropriate spot face cutter, or a sharp drill bit.

Before commencing component assembly, the board mounting holes should be drilled where shown on the layout diagram, with adjacent track breaks to prevent electrical shorts if metal mounting hardware is used.

It is recommended that the following assembly sequence is followed: IC socket, wire links, resistors, capacitors, semiconductors and terminal pins.

Make sure that the copper tracks are bright and clean before beginning to solder – a rub with a piece of emery cloth or a PCB cleaning stick would do the job. Keeping the soldering iron tip in a similar good condition also helps enormously! The result of a little care and attention here will be quick soldering, tidier joints, not to mention a more reliable construction.

CHECK IT!

When you have completed the assembly of your board, a few careful minutes should be spent rechecking the board layout: the component positions, wire links, all the track breaks and, most importantly, a close examination of the copper side for any dry joints, solder splashes, and "bridges" between tracks.

Time spent here can save hours later on. Once you have confidence in your efforts, the board can be temporarily fitted in the chosen box using stand-off pillars as necessary. Off-board connections to the circuit can also be added, these being the tricolor LED (D4), temperature sensing diode (D1) on a pair of flying leads, and power. This will allow you to make a basic bench test of the circuit and do a rough calibration.

Before inserting IC1, a couple of final checks are advisable. Measure the resistance across the power leads, and also between the +5V and 0V lines on the circuit board to see if there are any shorts that haven't been spotted. If all's well, remove the meter and apply 12V to the circuit.

Use the meter to check that IC1 is receiving a 5V supply across its power pins (11 and 4). Short wire extensions to the meter probes are useful to get into the IC socket holes. The LED should be glowing red at this time. If things are looking good, remove the power and install IC1 in its socket, not forgetting to take care over orientation and pins not being bent underneath!

CHILLY FUN!

Now for some fun and games with the circuit! Get some ice out of the fridge or freezer and put it in a small beaker with some tap water. After a few minutes, this should settle at 0°C and create the freezing point reference. Use a thermometer to check this if you wish.

Apply power to the circuit, and dip the sensor diode in the water (keeping the sensor away from the ice). Use a small screwdriver or trim tool to adjust the preset pot (VR1) until the LED is just into the flashing mode, i.e. flashing red/green. The pot is a multi-turn device, so it may take a few turns to find the right spot.

If everything's looking good, remove the sensor diode from the water, and allow it to warm up. The LED should stop flashing and turn to a steady red, and then to green. Finally, put the sensor back in the water and make sure it goes back "down" to the flashing state.

With the preliminary testing finished it's time to think about fitting the *Frost Box* to the car!

L.E.D. MOUNTING

Decide where you want to mount things in the vehicle. If everything is going on the dashboard, the LED can be mounted on the box itself. But, if a remote mounting solution is preferred with the box under the dash, the LED could be mounted in another small box, or in an unused vehicle switch location through a hole drilled in its blanking panel.

The positioning of the LED should be such that it is readily visible to the driver, and although the type specified is a high brightness device, care should be taken to avoid the upper dash areas where sunlight may cause "wash-out".

All wiring should be undertaken with care as there are various approaches to tricolor LED leg/terminal identification by different manufacturers (ask your component supplier to state which leg is which if it's not obvious from his catalog). Sleeving should be added around all wire connections to prevent short circuits, and to add physical strength.

SENSOR

Remove the temporary sensor diode (D1) from the board, and set about constructing the temperature sensor.

First you must decide where you're going to fit it and the general aim is to get close to the surface of the road. A good position would be behind the front number plate or bumper, because it is essential that the sensor is mounted in a sheltered position to reduce any wind-chill error to a minimum.

Another good spot is the front wall of a wheel arch. When a suitable site has been identified, measure the length of cable required to get you back to the circuit board, and cut a suitable piece of twin core screened cable. The cable screen reduces any pick-up of unwanted signals from the ignition system, and adds a bit of physical strength.

Remember that the cable route chosen must avoid fan blades, exhaust pipes, battery acid, etc.

WEATHER-PROOF

Since the diode will be exposed to the elements, it's a good idea to provide it with a bit of protection. The method adopted was to fit the diode inside an electrical "bullet" connector and surrounded by an epoxy resin. The author has found this to be a very reliable method. A sample has survived for well over five years in a wheel arch using this approach!

Prepare the cable by cutting back the external insulation and screen to expose just over a centimeter of the two signal wires. Take the sensor diode and trim the wires to leave about 3mm at each end, then connect the signal wires as shown in Fig.4.

Give the assembly a quick spray of conformal coating or lacquer. While this is drying, prepare a small amount of epoxy resin and fill the bullet connector. Make sure it's filled properly with no air trapped, then push the sensor carefully inside. Wipe off any excess epoxy and leave to harden in a warm place overnight.

To finish off, add a piece of heat-shrink sleeving to give some extra strain relief, and make it look like a professional job!

Finally, wire up the sensor to the circuit (taking care to get the polarity right), and go through the calibration routine once again. Only a fine adjustment of preset VR1 should be needed.

INSTALLATION

Having sorted out your preferred positions on the vehicle, it's time to start on the permanent installation. Before making any connections to the electrical system, it's sensible to disconnect the battery. To be really safe, add a 1A fuse in line with the supply to the unit, which should ideally be from an ignition-switched circuit.

Feed the sensor through to the chosen mounting position, securing it along the way with tie-wraps if available. The circuit works best if the sensor tip is mounted proud of any surface using, for example, a self-adhesive tie-wrap base, as seen in the close-up photograph.

IN USE

The author has found the *Frost Box* to be a most useful addition to his car.

The sensor assembly is very responsive, being able to quickly pick out cold "hollows" on the road where cooler air collects. The application of the circuit is by no means limited to vehicles, and could be easily adapted to use as a general-purpose temperature warning unit, such as a reminder to turn on a greenhouse heater.

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New Technology Updates

SURFACE ACOUSTIC WAVE DEVICES HAVE BEEN DEVELOPED TO ACT AS CHEMICAL DETECTORS. IAN POOLE REPORTS.

Surface acoustic wave devices are not everyday devices for the electronic designer. They are normally seen as being for use in a small number of specialist applications, particularly as filters.

However, it is likely that they will achieve widespread use in a role as chemical detectors in the future because, in a new development, they are able to provide an extremely compact detector.

WHAT ARE SAW DEVICES?

A surface acoustic wave (SAW) device uses a piezoelectric material as its base. Piezoelectric materials have the unique and very useful property that an electric potential applied across the crystal lattice will cause it to deform. The inverse is also true, such that when the material is stressed or deformed then an electric potential appears across it. This phenomenon is used in a variety of devices.

Piezoelectric transducers are quite common. They can be used as the basis of a cheap microphone, and many of the old pick-up heads used in vinyl disc record players used this principle. Now the technology is used for transducers found in vibration equipment and for sensing other forms of movement or vibration. The principle is also used for quartz crystals that can provide the resonant element in oscillators to give very stable signals or in filters to give high degrees of selectivity.

The principle is also used in surface acoustic wave devices. Here the device consists of a polished piezoelectric substrate that acts as a propagation path for the mechanical signals or vibrations. There is an input transducer that converts the incoming signal to a mechanical vibration and an output transducer that picks up the incoming signals and converts them back in to electrical signals. It is worth noting that the signal has a defined delay across the device and this fact is applied when the device is used as a chemical detector.

A basic diagram of a SAW filter is shown in Fig. 1. When a signal is applied to the input transducer it creates a mechanical vibration that propagates outwards from the electrodes along the surface of the material. The vibration passing away from the output transducer has to be absorbed otherwise it would reflect off the back surface of the material causing an echo, and an absorber is used for this.

When the signal propagating towards the output transducer reaches it the vibration is converted back into an electrical form. Again the signal that might pass beyond the transducer has to be absorbed otherwise it would cause an echo off the other surface.

The design of the transducers is critical to the operation of the device as a filter. Their length varies, but they are connected alternately to signal and ground. The signal is delayed by an amount determined by the spacing between the input and output transducers. The actual response of the filter is determined by the electrode spacing. As the signal arrives at the output it creates an oscillating impulse. The filter will give maximum output when the time for one cycle of the signal is the same as the time for the signal to travel from one of the signal fingers to the next.

NEW APPLICATIONS

Whilst SAW devices have chiefly found uses as filters in the past, a whole new area of applications is appearing. Developments have been undertaken at the USA's Sandia National Laboratories that use surface acoustic wave principles to enable traces of dangerous chemicals to be detected.

These detectors are being developed to detect a wide range of chemicals. This can be achieved because the devices based on SAWs form an extremely sensitive gravimetric detector that can be coated with a thin film to enable it to collect specific types of chemical. These devices are surprisingly sensitive and have been shown to be capable of detecting traces as low as a few parts per million, and in some cases they are expressed in terms of parts per billion.

With the ability of these devices to detect chemicals with such low levels it opens an enormous number of possibilities. They are expected to be used in a wide range of applications including monitoring the state of the environment and other health aspects.

Normally transducers for this type of application are made using a quartz substrate. However, those in this development were fabricated using gallium arsenide as the substrate because this semiconducting material also exhibits the piezoelectric effect.

The use of gallium arsenide means that not only is the chemical sensing transducer integrated onto the substrate, but so are the associated electronics. This enables the whole assembly to be contained on a single piece of gallium arsenide little larger than a button and enabling the whole testers to be made very small and easy to carry.

The transducer itself is made by fabricating the surface acoustic wave device. A thin selectively absorbing polymer layer is then applied into the piezoelectric surface. It is found that when specific chemicals are absorbed, the surface acoustic waves travel more slowly across the device. By analyzing very closely the delays on the signals the chemicals can be detected and analyzed.

One of the chief concerns of the development team was that the integration of the transducer and the electronics onto the same chip would degrade the performance of one or both of the functions. This might occur because the fabrication techniques would not suit both of the technologies as they could have conflicting requirements.

The development team addressed this possible problem from the outset. They were able to design the surface acoustic wave device so that it would use traditional integrated circuit fabrication techniques. Once this had been achieved the task became much simpler and neither area of the development was compromised. Naturally, the advantages of being able to integrate both electronics and detector onto the same substrate are enormous in terms of convenience and overall performance.

One problem did need to be overcome. To ensure high degrees of reliability integrated circuits are normally sealed and not exposed to the atmosphere. However, the sensor obviously needs to be exposed. This was overcome by using a "lid" that was attached directly onto the gallium arsenide surface. Several channels were machined into this to allow the gas to flow over the sensor whilst still protecting the remaining parts of the circuit from contaminants that might degrade the performance of the electronics over time.

COMPLETE UNIT

With the ability to have the sensor and electronics on one chip, the possibilities for having a small yet advanced detector are enormous. The ultimate aim is to produce a handheld chemical detection system.

This would not only incorporate the sensors with their associated electronics, but also a computer to enable much of the advanced processing to be undertaken. Although this may still take some more time to perfect, units like these will undoubtedly be extremely useful in many applications.

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SURFING THE INTERNET

Net Work

By Alan Winstanley

HALF A DECADE ON

How time has flown: it's hard to think that 1995 was the year in which work started on the development of a web site for *EPE Magazine*. In the absence of any precedents, I decided early on that the best place to find out what potential users really wanted would be to listen in on Usenet (using my DOS-based newsreader). Reading the now defunct newsgroup **sci.electronics** (where, incidentally, I met Clive Maxfield, who now is the co-editor/co-publisher of *EPE Online* in the USA), it became apparent that the microcontroller was here to stay and that it would probably form the basis of all but the very simplest logic circuits in the future.

You said that hobbyists and constructors wanted the source codes for microcontrollers to be given away for free. After all, you argued, without the source code we may as well not publish a circuit diagram or the PCB foil either: simply solder the chip into place along with the other parts and away you go. Hardly likely to be very satisfying for the average electronics constructor though, especially if they want to learn from the experience or wish to tweak the source code for their own applications.

At a very early stage we decided to provide the source codes for transfer by anonymous FTP. No matter where readers lived, provided that they had Internet access they could obtain nearly all our source codes for our PIC and Atmel project files, completely free. Suddenly, overseas readers were able to obtain codes instantly instead of waiting two or three weeks for a floppy disk to arrive from the UK. You were overjoyed!

The web service proper launched in September 1996, followed by secure on-line ordering of subscriptions and back issues. The *EPE Chat Zone* was added later on, and this asynchronous message service has now been extended to our sister magazine *Radio Bygones*, which has been given its own "Message Board" (**www.epemag.wimborne.co.uk/radiobygones/wwwboard**).

EFFECTIVE SUGGESTIONS

Occasionally I receive readers' suggestions for future developments. Some ideas come under the heading of "Nice but not really feasible", such as posting older magazine indexes onto the web, or trying to publish old magazine articles: the difficulties here are that some parts become obsolete, or the design becomes so long in the tooth that it is increasingly less rewarding to build that circuit, and trying to support readers who may be struggling with ancient designs becomes very challenging indeed for the Editorial team. There may be scope for publishing basic "starter" projects from old issues though.

I concurred with one reader's suggestion in that it would be nice to publish the project PCB CAD files so that users could download them straight into their local systems and accurately fabricate the board that way. The problem is the wide variety of software packages used by our contributors. We need "camera ready" artwork to input into our own graphics software, so it is difficult to standardize on, say, gerber output or whatever. Another suggestion is to publish *EPE* on CD ROM. Well we're nearly there, with our International version available from **www.epemag.com** and anything is possible in the future.

At this stage we can also say that a complete overhaul and redesign of the *EPE* web site is very much on the cards *(this is the site for the hard-copy edition of EPE at* **www.epemag.wimborne.co.uk***, not our site for EPE Online at* **www.epemag.com**, *Ed)* but when all our resources are focussed at getting the printed magazine out on time every month – writing this column at midnight to meet tomorrow's deadline is more important than posting the 1999 Index! – we hope you can be patient. One thing's for sure, the Year 2000 will be an exciting one at *EPE* and *EPE Online*. Tell us what you would like to see.

PET HATES

According to a Webpedia poll (**www.webpedia.com**) published for the benefit of web designers, the average web site visitor may be sufficiently irritated by the following factors to cause them to give up and go look elsewhere. The users'

biggest complaint, said the poll, related to long loading times, caused mainly by bloated and superfluous graphics. Using images to display words without also offering an alternative text-only navigation aid is bad form.

Next came the much-hated "File Not Found" (404) error messages, a sort of cyber-slap in the face for navigating around the site only to eventually hit a brick wall. The third most common cause for complaint was the way in which some links, banner adverts etc. entice users to click on them but actually misled users. Badly described links of this nature came in for some criticism.

Moving down the scale of annoyances, respondents highlighted complicated-looking navigation aids followed by unappealing-looking pages as culprits. Last of all, long pages that need scrolling to view their content, came in as a feature which was least likely to force users to go elsewhere.

At the end of the day, people look at web sites for information. My sister-in-law checked the web site for a particular product, but couldn't see the local distributors listed anywhere and therefore considered her search a total waste of time. A site's visual appeal came very near the bottom of the list of pet hates and there is now a trend toward the use of simple, solid color (which loads fast in standard HTML) instead of bloated graphical images.

Apart from that, the Webpedia survey would seem to confirm the future trend for fast, blippy web pages which I guess reflects the likely nanosecond attention spans of tomorrow's Internet generation.

THE END IS NIGH

In the early days of the *Net Work* column, I wrote about this strange thing called "Y2K". At that time all talk about the Year 2000 Bug was strictly the domain of the professional, managerial and technical sectors, certainly not of the UK public, a minority of whom were too busy trying to surf the net at 14.4Kbps on a dodgy connection. An increasing amount of public uncertainty about Y2K caused people to fret about simple electrical appliances failing and airplanes falling out of the sky at midnight, December 31st 1999.

If you have a 486-based PC or earlier, there is every chance that it may be affected by the Year 2000 date and leap year rollover bug. You can apply a simple patch that will fool the computer's clock into thinking that 2000 has arrived, and this is available free for personal use from *EPE Online* at **www.epemag.com**. Enter the main Library, then click on the "Code Files" link to find the **year2000.zip** file.

Our Y2K patch is kindly provided by Tom Becker (no relation to our Tech Ed!) of RighTime Inc. in Miami, USA (**www.RighTime.com**). The program **year2000.com** is a small resident program for DOS, OS/2 and Windows that fixes the year 1999 to 2000 date change flaw of the CMOS RTC (Real Time Clock) in AT-class PCs and PS/2s, 286 through Pentium and its clones. I use it on an old 486, and it's free for personal, non-business use (a licensed business version is available separately).

Even if your hardware is Y2K proof, you should check any software which timestamps any events, including PIMs, email, or accounting software. Also keep a wary eye for the February 29 Leap Year rollover as well. I wonder what H.G. Wells would have made of Y2K when he wrote *The War of the Worlds* 101 years ago, when a bug of a different sort actually saved the Earth from near oblivion.

To all *Net Work* readers everywhere – compliments of the season and I wish you a Happy New Year.

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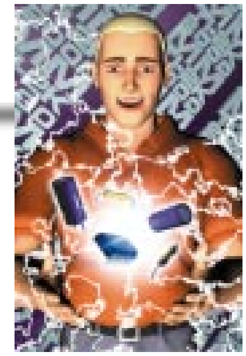
TEACH-IN 2000



PART Three - Potentiometers, Sensor Resistors, Ohm's Law

by John Becker

What we are doing during this 10-part Teach-In 2000 series is to lead you through the fascinating maze of what electronics is all about! We are assuming that you know nothing about the subject, and are taking individual components and concepts in simple steps and showing you, with lots of examples, what you can achieve, and without it taxing your brain too much!

Through these simple steps we hope to prove to you that using electronic components need not be a complex task and that, providing you think about each stage of what you are trying to create, you can actually design and build something that works!

Last month we introduced color codes and resistors. We now look at capacitors and show you some of the things they can achieve when used with resistors.

Concluding the *Experimental* portion of last month's article, we left you with the suggestion that you should try getting the oscillator to run at an exact frequency of your choosing.

What must have become apparent to you, though, is that resistors and capacitors of fixed values needed to be used in - multiples to achieve specific timing values – not a convenient matter. But hopefully you found it interesting to play around with various combinations.

Doing so will have helped to reinforce your understanding of calculating RC relationships with resistors and capacitors in series or parallel. Excellent – but now we are going to demonstrate a method of frequency control that does not require that amount of brain power!

In Fig.3.1 is a modified breadboard layout to that shown last month in Fig.2.14. The modification is the inclusion of component VR1 in the feedback path between IC1 pin 6 (Vout3)

Photo 3.1. A selection of potentiometers: single and dual controls with shaft, plus four miniature preset types suited to printed circuit board mounting.

and resistor R1 (Vin). This component has various names, which we state presently. For the moment just call it a preset.

Delving into your bag of components, and referring to Photo 3.1 (see the first small item at the left) choose a preset that has the value 100k printed on it (or a coded value of 104, which means 10 plus four zeroes = 100000 = 100kΩ).

Using this preset as VR1, modify your Fig.2.14 board layout to that in Fig.3.1. Also change the value of resistor R1 to 1kΩ. There is slot at the top of the preset, which can be rotated back and forth using a small screwdriver. Now you'll find it much easier to change the circuit's frequency!

With hands on experience of this newly introduced device, let's examine the realm of variable components in general.

VARIABLE RESISTORS

Irrespective of the material used to make them, conventionally, "ordinary" resistors are regarded as belonging to one of two physical types: fixed resistors and variable resistors, the latter more commonly known as potentiometers. There are also sensor resistors, whose value is also variable; they will be discussed later in this Tutorial.

First, let's examine

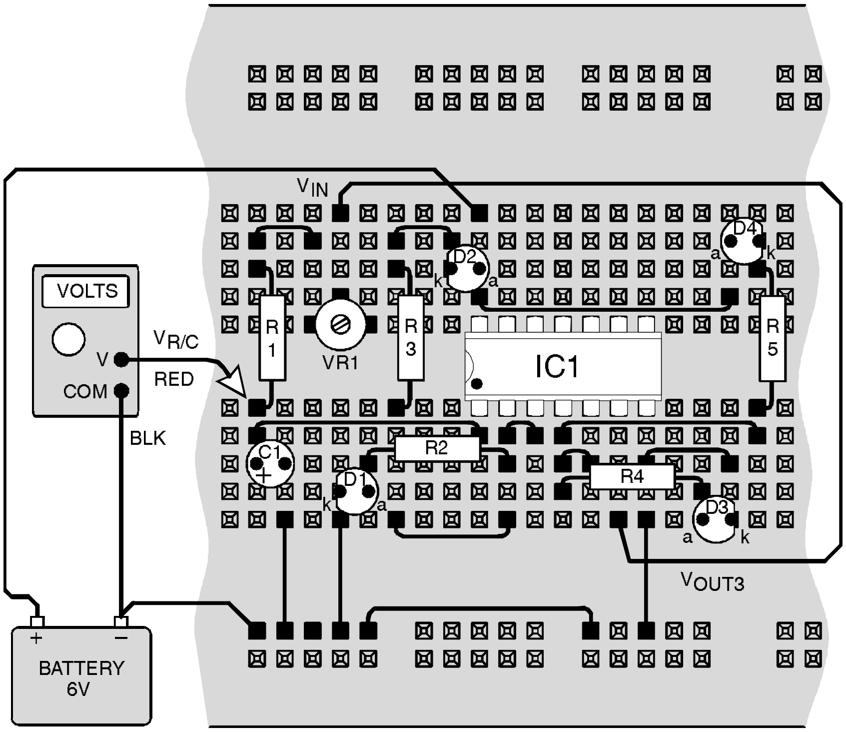


Fig.3.1. The oscillator of Fig.2.14 (Part 2) modified to include a preset potentiometer for variable control.

potentiometers, which are resistors with a sliding contact that allows us to set an exact value of resistance at that point and, by implication, to set not only precise current flow values, but also precise voltage levels. This family of components makes life so much easier when fine-tuning a circuit to your needs – as you've just found!

Circuit diagram symbols for potentiometers are shown in Fig.3.2. As with resistors, there are two standards in common use, zig-zags and boxes. Other differences between the symbols will become apparent. As we said in Part 1, *EPE* and *EPE Online* have standardized on zig-zags.

POTENTIOMETERS

A basic potentiometer has three connections or terminals (as you will see from the symbols in Fig.3.2a and Fig.3.2b). As with a fixed resistor, there are two connections at either end of the resistance material, which is commonly known as the track. The third (middle) connection is made to a conducting slider, commonly known as the wiper, which is in contact with the track and can be slid along it from one end to the other.

The current or voltage available at the wiper is related to the position that it has along the track. It should be noted, however, that the basic resistance of the component itself does not vary, it is only the relative resistance between the wiper and each end terminal that can be varied.

Physically, potentiometers fall into two main types: first, there are the control potentiometers, those that have a shaft or tab which usually protrudes through the panel of the case in which the circuit is mounted.

This type of potentiometer is intended where frequent correction of its wiper position is required, such as when it is used as a volume control, for example. The symbol for this type of potentiometer has a small arrow on the middle line representing its wiper (Fig.3.2a).

The other type is commonly known both as a *preset potentiometer* (or just preset) and as a *trimmer potentiometer*. A preset is normally a much smaller component than a control potentiometer and is usually mounted on a printed circuit board. As you have just found, it has a slot by which it can be adjusted using a small screwdriver or similar tool.

Presets are usually intended to be adjusted to set an exact resistance or voltage value, which may seldom need to be adjusted again. The symbol for a preset does not use an arrow on its wiper, but a short line shown in parallel to the track outline (Fig.3.2b).

CALLING THE POT

It's worth noting that the use of the term potentiometer (often abbreviated just to pot) may in many circumstances actually be an incorrect use of the term. In strict definition, the correct term is really as we first named it, variable resistor, even though its actual resistance along the full length of the track does not change.

Strictly speaking, the term potentiometer applies only when the variable resistor is used as a potential divider whose output potential (voltage) at the wiper can be varied, a situation in which all three terminals of the device have to be used. (You met the concept of a potential divider

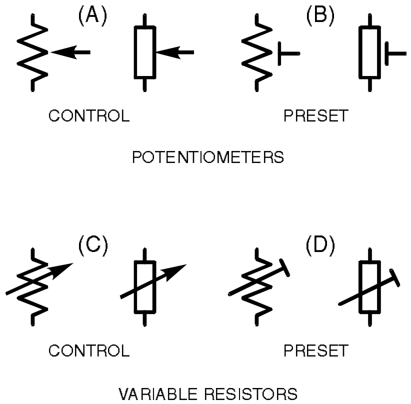


Fig.3.2. Typical potentiometer and variable resistor symbols.

when resistors in series were examined in Part 1.)

There are many instances, though, when the voltage is not the condition that needs to be varied, but rather the resistance. In this case only the wiper and one other terminal need to be connected, and the true description of variable resistor is the one which should be used rather than potentiometer. There are specific symbols that are commonly used in this situation, as shown in Fig.3.2c and Fig.3.2d.

Even though only two terminals need to be used, it is usually desirable to connect the third terminal of a variable resistor to the wiper. This ensures that a minimum circuit resistance still exists even if the wiper comes away from the track in a fault condition.

Control potentiometers are available as rotary shaft and slider types, both of which are manufactured in single and dual configurations. Photo 3.1 shows standard single and dual rotary types (top left and right in the photo) – see a major component supplier's catalog for illustrations of the other types.

Dual rotary types have two tracks and wipers mounted in separate enclosures, secured one behind the other, and are available in two versions.

The dual tandem type has a single shaft, which controls both wipers at the same time. The dual concentric type (which is not commonly available) has two shafts, one within the other, which allows each wiper to be controlled separately.

Dual slider pots have a single tab, which controls both wipers simultaneously.

LINEAR AND LOGARITHMIC

All control potentiometers have a choice of track resistance type: linear, logarithmic, or anti-logarithmic, terms which are commonly abbreviated to lin, log and anti-log.

Linear tracks have the same change of resistance per track length along the whole of the track; in other words, the output at their wiper changes linearly with linear movements along the track. With logarithmic tracks, the resistance per track length step changes along the track, by a small amount at one end, progressing logarithmically to a larger amount at the other; in other words, their output varies logarithmically with linear movements along the track.

Logarithmic rotary types have the minimum track-to-wiper resistance change with their shaft rotated fully anti-clockwise (to the "left"). Anti-log types (rarely available from retail sources) behave in the opposite direction. Slider pots (not illustrated) are not made as anti-log versions – just turn log types round the other way!

Some rotary pots and presets are available as multi-turn varieties; the adjustment shaft is geared so that the wiper rotation is less than the shaft rotation. These pots are only available in single, linear forms. An example of a multi-turn preset is shown in Photo 3.1,

PANEL 3.1 – POTENTIOMETER TYPES

o) Panel mounting, rotary with shaft.
sub types: single, dual tandem, dual concentric, linear, log, anti-log, multi-turn linear.

o) Panel mounting, slider with tab.
sub types: single, dual tandem, linear, log.

o) Printed circuit board (PCB) mounting, rotary with shaft.
sub types: single, dual tandem, dual concentric, linear, log, anti-log, multi-turn linear.

o) PCB mounting, slider with tab.
sub types: single, dual tandem, linear, log.

o) PCB mounting, preset rotary with adjustment slot.
sub-types: vertical or horizontal mounting, open (skeleton) or enclosed tracks. All tracks are single, linear.

o) PCB mounting, preset slider with screw adjustment.
sub-types: vertical or horizontal mounting, single turn or multi-turn. All are enclosed and all tracks are single, linear.

All pots are available in a variety of body and shaft or tab sizes. Anti-log and dual concentric types are only available through specialist suppliers.

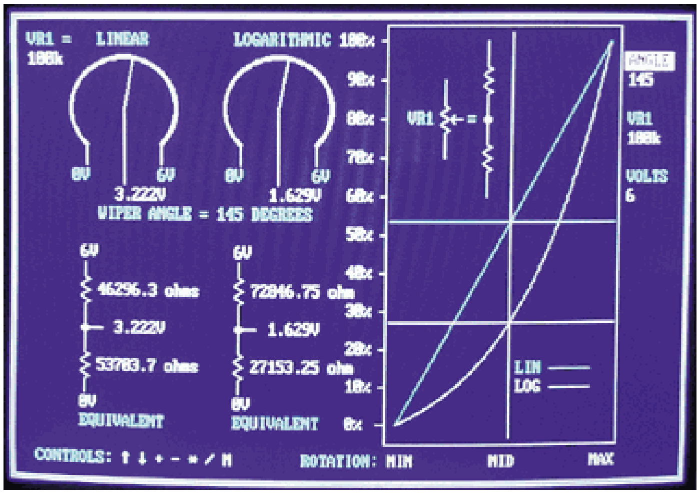


Photo 3.2. Linear and logarithmic control potentiometers illustrated on the interactive computer screen.

see the small “square” device (other types exist).

POTENTIOMETER PROGRAM

We have set up a software program that illustrates the difference in response between linear and logarithmic potentiometers. From the main menu in the *Teach-In 2000* software (which is available for free download from the *EPE Online Library* at **www.epemag.com**) select option *Potentiometers*. See Photo 3.2.

At the top left of the screen are two nearly-circular yellow arcs. These represent the resistive tracks of a rotary potentiometer. The wiper of each pot is represented by the white line angled from the centre of the arc to its left-hand end. This line’s angle can be changed by using the <+> (plus) and <–> (minus) keys for angle steps of 1, or <*> (multiply) and </> (divide) for steps of 10. Try them.

The angle between the start and end of each pot’s track is approximately 270°. This is the typical angle through which an average pot’s track is effective. Note that there are slight differences of maximum angle between pots from different manufacturers. Some pots may also have a greater physical angle of wiper travel than their track.

You will have noticed a lot of screen activity occurring when you pressed the <+> and <–> keys. The first point of interest is that the voltage shown at the line connecting vertically to the wipers changes according to the rotation angle. It is also relative to the voltage between the left and right hand ends of the track, which at present is shown as 10V.

You also will have seen that the wiper voltages of the two pots are significantly different for most positions around the track. The progressions are, of course, linear and logarithmic respectively. The two graphs at the right of the screen illustrate how the wiper voltages change with their positions along the tracks.

EQUIVALENT RESISTANCES

Looking to the right of the pot arcs, the symbol for a control potentiometer is shown. As we mentioned earlier, the arrow pointing to its central position represents the wiper. To the right of the symbol are two resistors in series. These represent the equivalent resistances between the wiper and the two outer terminals.

The twin-resistors are repeated below each pot arc and there you will see that the resistance values for each section of the pot are numerically shown in ohms. Additionally, the voltage at their junction (the wiper) is also given, and is identical to that in the illustrations above them.

As you change the rotation angle, its numerical value in degrees is shown top right of the screen.

Within the graph area, three movable lines are shown. The white vertical line represents the position of the wiper, with a simple Min, Mid and Max notation along the bottom edge of the boxed outline.

The green and yellow horizontal lines represent the percentage rotation of the wipers, lin and log respectively. The position where these lines cross the movable vertical line and the graph line of the same color is the relative co-ordinate for the wiper.

The graph illustration is really only for interest and has little practical application. It’s the voltage and resistance numerical values that are of greatest significance.

PROGRAM VARIABLES

The potentiometers are each of the same value, 100kΩ as shown. This can be changed by using the up or down arrow keys to highlight VR1 on the

right-hand side.

Potentiometers are normally only available in values of three steps per decade: 1, 2·2 and 4·7. Some manufacturers use steps of 1, 2·5 (or even 2) and 5. Normally, it doesn't matter which group you use – 2·2 can be used in place of 2·5, and 4·7 can be used in place of 5 (and vice versa).

Potentiometer VR1 values can be changed using the arithmetic keys (with the same steps as for the angle). The range is from 100Ω to 10MΩ (2M2 is generally the maximum value available to buy).

The voltage across the pots can also be changed when VOLTS at the screen right is highlighted. Use the up/down keys to access it, and the arithmetic keys to change it. As with our other software menu options, the voltage steps are in 1V, from 1V to 10V.

There are no self-test exercises for this display, which is purely for informative demonstration.

PANEL 3.2 – TRACK TYPES

- o) Carbon film. General purpose.
- o) Cermet (ceramic-metal). Precision (cermet tracks have a less coarse nature than carbon, resulting in a smoother change of resistance when rotated).
- o) Conductive plastic. Precision – smoother wiping.
- o) Wire-wound. Higher wattage rating.
- o) Wire-wound, very heavy duty, lengthwise with slider, as sometimes used for stage lighting control and often known as a rheostat – not really an electronics component.

Not all track types are available in all physical forms – see major supplier's catalogs.

Apart from the mechanical and physical specifications listed above and in Panel 3.1, the other principal parameters for a potentiometer are the same as for fixed resistors:

- o) Value of the resistance track, which may be expressed in ohms (Ω), thousands of ohms (kilohms, kΩ, or KΩ) or millions of ohms (megohms or MΩ). Standard values are 1, 2·2 (or 2 or 2·5), and 4·7 (or 5) in decade multiples of 100, 1000 (1k), 10000 (10k), 100000 (100k) and 1000000 (1M up to 2M2).
- o) Power rating in watts (W).
- o) Resistance tolerance, expressed as a percentage of its set value.
- o) Temperature coefficient, expressed as the amount by which the set value will change with temperature, variously expressed as parts per million (ppm) or percentage change per degree Celsius (%/°C).

As we implied earlier, most pots are incapable of being rotated through a full circle. About 270° is an average maximum wiper rotation around the track, at which point the track ends and there is usually a tab to prevent further shaftrotation.

However, at a price, pots with a track rotation angle approaching 360° can be found from specialist suppliers, those dealing with robotics and other automation supplies, for example.

Shaft rotation angles may sometimes be greater than track angles, and some shafts may rotate through 360° even though the track does not. Good catalogs normally quote rotation factors.

NOTATIONS

In circuit diagrams and constructional charts, a potentiometer's numerical identity may be prefixed by "VR" (Variable Resistor), e.g. VR1 as we used earlier, and in the computer display, or "RV" (Resistor Variable) or "P" (Potentiometer) or even "PR" (Preset Resistor).

Logarithmic pots are normally notated as such on circuit diagrams. Linear pots are not always notated accordingly; if the pot is shown without a lin or log notation, it is a linear type unless an associated components list states otherwise (barring circuit drawing errors, of course).

Potentiometer identities are usually printed on them in text and numbers, although some presets may be color-coded in resistor fashion. As you may have discovered, presets may also have a coded value of the form 104, where 4 states the number of zeroes following the 10; in this instance the preset's value is 100000 ohms (100kΩ).

There is a wide variety of general and specific information on potentiometers in Panels 1 to 3, and it would be a good idea to read through these now.

SENSOR RESISTORS

We shall now tell you a bit about some other groups of components that come into the resistor category – sensor

PANEL 3.3 – SHAFTED!

Rotary control potentiometers are generally supplied with a shaft that is considerably longer than usually required. The shafts may be metal or plastic and require cutting to length, an action that can be hazardous to the pot's track if not done carefully.

Don't hold the body of the pot in a vice and then cut the shaft with a hacksaw – the sawing action and consequent movement of the wiper against the track can damage both. At the very least resulting in uneven contact of the wiper with its track and consequent poor electrical results when turning the pot.

Instead, put the shaft in the vice to clamp it, then saw through it, gently holding the body end to stop it falling when the cut is complete. Carefully file down any burrs on the shaft, to allow a knob to slide on easily.

resistors.

Environment-sensitive resistors known as varistors (VDRs), thermistors, and light dependent resistors (LDRs) are a special class of resistor whose resistance changes in response to changes in voltage, temperature, and light, respectively. Unlike the potentiometer, which is often called a variable resistor, even though the actual resistance between its ends is fixed, these three component types have a resistance that literally changes according to ambient (surrounding) conditions.

Circuit diagram symbols that might be encountered for these components are shown in Fig.3.3. The symbols are similar but have specific identifying features: the dot or notation beside the thermistor signifies its temperature sensing nature; the arrows pointing at the LDR signify light falling on it; the VDR is without any additional feature beyond the angled line with a "kink" at the top through the resistance symbol to indicate inherent variability, although an operational voltage may sometimes be quoted alongside the symbol. All three types of sensor resistor are not polarized and may be connected either way round.

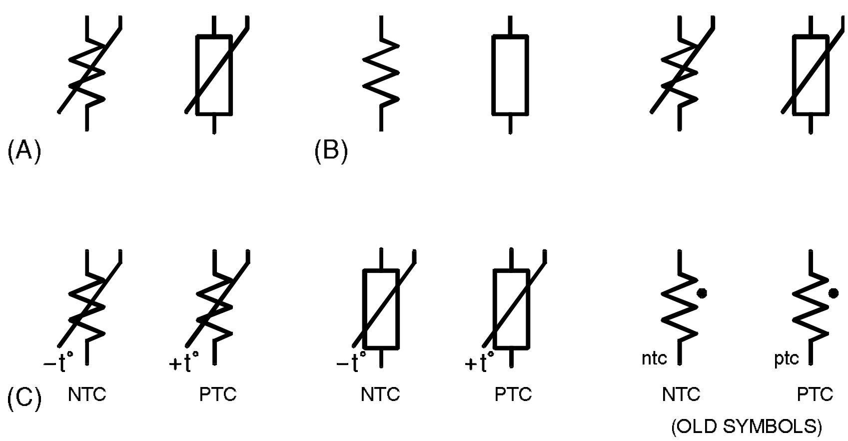


Fig.3.3. Typical Sensor resistor symbols: (a) voltage dependent (VDR); (b) light dependent (LDR); (c) temperature dependent (thermistor). (Symbols may be circled.)

Let's examine the three sensor types in turn (and put one of them to use in the *Experimental* portion of this article – an LDR).

LIGHT DEPENDENT RESISTORS (LDRs)

As the name implies, a light dependent resistor (LDR) is a device whose resistance changes in response to the amount of light falling on it. An LDR's resistance value in the presence of strong light is just a few ohms, but in the absence of light the value can be many tens of megohms (millions of ohms).

A typical resistance/ illumination graph is shown in Fig.3.4. Note how non-linear is the LDR's response. The base material from which LDRs are made is cadmium sulfide or lead sulfide.

The LDR you will be most likely to use is the ORP12 (or the equivalent NORP12), and is one of the components we recommended that you bought for this *Teach-In*. There are other types available, but less commonly. A really nice example of a miniature type is the VT935G used in our *Musical Sundial* project of June '99.

An important characteristic specified for LDR types is the spectral sensitivity (sensitivity to different colors of light and expressed in nanometers – nm) which indicates how the resistance varies depending on the wavelength of light reaching the device. Types are available which respond to infrared and ultraviolet wavelengths as well as "visible" light.

The value of LDRs is usually quoted in relation to their resistance at a particular wavelength and intensity. Since

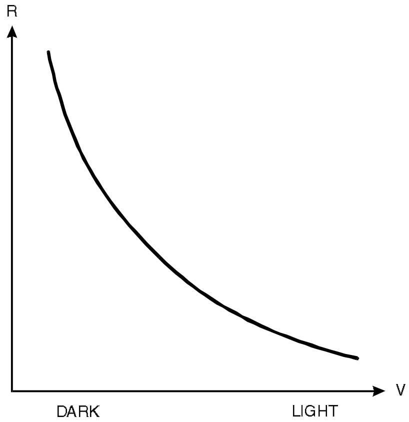


Fig.3.4. Typical response graph for an LDR.

LDRs are purely ohmic (resistive), they can be used in both AC and DC circuits.

It is worth noting that LDRs are fairly slow in their response to changing light levels, consequently circuits which require a high speed response, such as in optical communications systems, use photodiodes or phototransistors (discussed in a future part).

In circuit diagrams and constructional charts, a light dependent resistor's numerical identity may be prefixed by "R" or "LDR". In component catalogs, LDRs may be listed under "Optoelectronics" rather than under "Sensors" or "Resistors".

THERMISTORS

The term thermistor could, perhaps, be abbreviated to TDR (Temperature Dependent Resistor) to more accurately describe its function, although this is not common practice. There are two basic types of thermistor, one of which is described as having a positive temperature coefficient (PTC) and the other as having a negative temperature coefficient (NTC).

The main characteristic of a thermistor is that its resistance changes according to its temperature – a reduction in resistance with increases in temperature for an NTC type, and vice versa for a PTC type. It is the NTC type that we recommended that you bought for this *Teach-In*. A typical graph for a PTC type is shown in Fig.3.5; an NTC graph smoothly descends with a similar degree of curvature (as in Fig.3.4, for example). You will notice that thermistors also have a non-linear response.

Thermistors are available in metal, glass, ceramic, and plastic cases. Their body shapes include discs, studs, probes, rods, and beads. Types are available which can sense temperatures between –80°C and 400°C, though the ranges for which they are specifically designed are narrower than these extremes.

Resistance values for thermistors are quoted in relation to that which exists at a specific ambient temperature, e.g. 10k (ohms) at 25°C. Tolerance factors are also quoted, such as ±0.2°C between 0°C and 70°C, for example.

Thermistors are likely to be found as circuit protection elements, and as sensing and corrective elements in measurement and control systems. However, since the advent of sophisticated integrated circuits, which have linear temperature sensing characteristics, the use of thermistors as separate entities has become less common in many applications. They still find favor, though, where low costs or simplicity are important. Diodes can also be used in some temperature sensing applications.

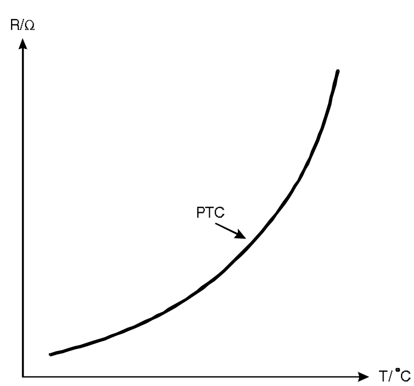


Fig.3.5. Typical response graph for a PTC thermistor.

Until you know more about electronics generally, it is probably best if you only use the types of thermistor you see specified for particular constructional projects.

In circuit diagrams and constructional charts, a thermistor's numerical identity may be prefixed by "R", or perhaps with "TH". In component catalogs, they are likely to be listed under "Sensors".

VARISTORS (VDRs)

The abbreviation VDR is often used in place of the term varistor and more accurately defines its function as a Voltage Dependent Resistor. VDR.s are devices that you will seldom encounter in normal hobbyist projects, but we include mention of them so that you know they exist!

When VDRs have a voltage connected across them, their

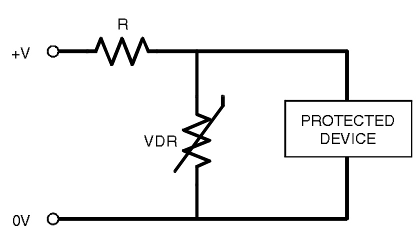


Fig 3.6. Use of a varistor to protect a component or circuit from excess voltage.

resistance depends on the value of that voltage. At a low voltage, the resistance is high, but as the voltage rises so the resistance decreases accordingly, but non-linearly (similar to Fig.3.4).

With this property, VDRs are often used to protect components that are sensitive to excessive voltage. In this application, they might typically be preceded by a normal fixed resistor such that the two components behave as a variable potential divider, as shown in Fig.3.6. If used without the additional resistor, changes in voltage level across the VDR would simply result in a change in the current flowing through it.

VDRs are typically made from a metal oxide material. They are available in many values for specific voltage ranges. There are other types of voltage suppression components made as silicon-based semiconducting devices. Diodes can also be used in some voltage suppression applications.

In circuit diagrams and constructional charts, a varistor's numerical identity may be prefixed "VDR" (Voltage Dependent Resistor) or just by "R" (Resistor). In component catalogs, varistors may be listed under "Suppression" components rather than under "Sensors" or "Resistors".

OHM'S LAW

Having now covered the basic resistive components that you are likely to come across, we feel we ought to tell you more about Mr. Ohm and what he achieved for electronics with his famous Law.

George Ohm was one of the great researchers into the phenomenon of electricity and

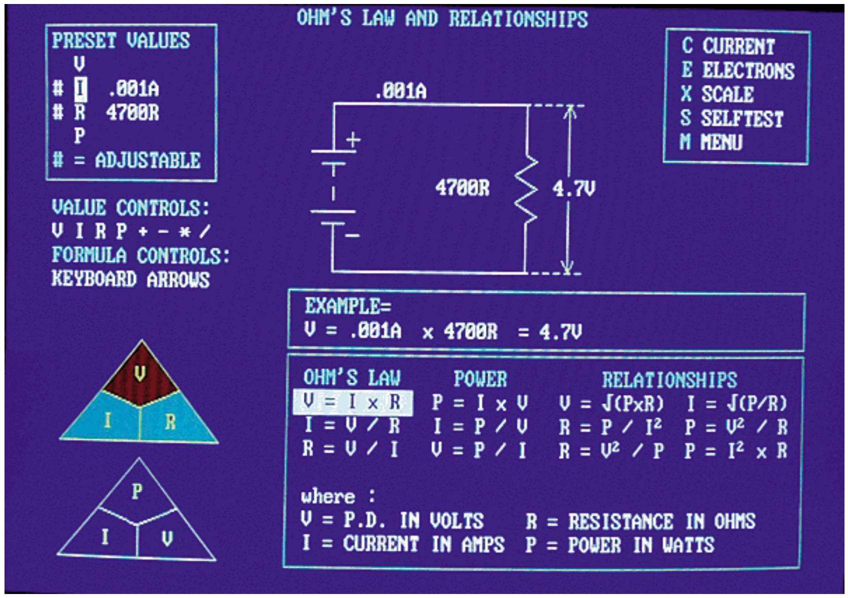


Photo 3.3. Ohm's Law and its relationships as illustrated via the interactive computer program screen.

its effects. We gave his dates in Part 1. He proved that there was a precise relationship between voltage, resistance and current, which can be expressed as:

Volts = Current x Resistance

which is usually abbreviated to:

V = I x R

where:

V = voltage in volts
I = current in amps
R = resistance in ohms

Letters V and R in the formula are obvious, Volts and Resistance. You will recall from Part 1 that current is measured in amps (amperes), symbol "A", but symbol "I" for current in Mr Ohm's formula – why on earth? Well, we are addressing you in English and quite naturally you might expect A for Amps to be used in the formula. In fact, "I" stands for Intensity and derives from a similar word in another European language (Italian we think – would anyone care to clarify this?). Anyway, by international agreement, I for current is what we're stuck with!

As anyone who's been to (or is still at) school should know, from a simple formula like this, two others can be derived:

I = V / R and R = V / I

As we shall see, a total of 11 other relationships can be traced back to the basic formula of V = I x R, but for the moment do try to memorize at least one of the first three, because they are invaluable!

CURRENT RECALL

On your computer go back to the *Teach-In 2000* software's menu option *Resistors in Series and Parallel*. Underneath each of the three simple circuit diagrams it shows not only the total resistance offered by the particular combinations of resistor values, but it also shows the current that will flow through the total resistance relative to a specified voltage across it.

Take the case where all three resistors each have a

value of 10kΩ, and the voltage supplied is 10V. The current is stated to be 500mA, 2mA, and 3mA in order of the combinations.

For the two resistors in series, which have a total resistance of 20kΩ, the Ohm's Law variant applied is:

I = V / R

In other words

I = 10V / 20kΩ

However, we cannot establish a proper answer as this stands, because the values are expressed in different decade multiples. We need to convert them to the common standard specified by the formula – V in volts, R in ohms, and I in amps. V can stay as it is since it's already in volts, but we must convert 20kΩ back to its base value of 20,000 ohms. This now gives us:

I = 10V / 20000Ω = 0·0005A

If we want, we are now free to express the current in milliamps and microamps by multiplying by 1000 and 1,000,000 respectively:

0·5mA and 500µA

the latter being the value as expressed on the display screen.

For the two resistors in parallel:

I = 10V / 5000Ω = 0·002A = 2mA = 2000µA

and for the three resistors in parallel:

I = 10V / 3333·333Ω = 0·003A = 3mA = 3000µA

Set up other resistance values through the program *Resistors in Series and Parallel* and check that your calculations of the currents tally with those shown on the screen.

Now turn the questions around and ask yourself, for example:

If R = 4kΩ and I = 2mA then what is V?

and:

If I = 3·2A and V = 8V then what is R?

The answers to both these questions can be provided via the program display with suitable selection of R and V values (after you've done your best to solve them, of course!)

Invent some other situations that test your ability to compensate for units not expressed in the value form required. Include values expressed in V, mV, mV, Ω, kΩ, MΩ, GΩ, A, mA, µA and pA (picoamps).

OHM'S LAW PROGRAM

When you've tested yourself with that last suggestion, and realised that, simple as the formulae are, they take a bit of thinking with your calculator, have a look at menu option Ohm's Law and Relationships (see Photo 3.3).

There is a lot of information offered through this screen's options. It will be of enormous value to you in the future if you want the computer to provide answers via the 12 formulae shown.

In the main box, you will see the three formulae for Ohm's Law itself. The next column shows three very similar-looking formulae to do with power calculation. The next two columns show the six formulae that can be derived from the previous two columns.

At present, you should see that Ohm's Law V = I × R is highlighted. This highlight can be moved to any of the other formulae using the arrow keys. Try them and then return to V = I × R.

OHM'S LAW TRIANGLE

You can't help but notice how other things change on the screen as well when you press the arrows. Let's take the upper-most of the two triangles first. It shows a very easy way of visualizing Ohm's Law.

Observe how the letters V, I, and R are arranged, and how V is shown on a red background. This illustrates the formula V = I x R, notice that I and R are alongside each other.

Press the down arrow once to select I = V / R. See how it is now I that has the red background, and how V is shown over R? Another press of the down arrow shows the triangle arrangement for R = V / I, with R now having the red background, and V is shown over I.

The coloring is unimportant, but the position of the three letters within the triangle is extremely useful to remember.

Press the down arrow again to make the highlight enter the Power column, with P = I x R selected. The second triangle has now come into play. Again the order of the letters and the way they are positioned illustrates the highlighted formula. Press the down arrow for the other two power formulae.

There are no visual aids for remembering the Relationships formulae (what a shame!).

Again return the highlight to V = I x R, then look at the simple circuit diagram shown, in which a battery is connected to a resistor.

Three values are shown, the resistor value in ohms (where the capital R is used in place of the Ω symbol), i.e. 4700Ω, a battery voltage of 4·7V across the resistor, and the current flowing through this closed circuit, 0·001A (note that the program drops any leading zeroes in a number).

SEE HOW IT FLOWS!

Before discussing the circuit values, let's show you something that's a bit of fun (but, at the end of the day, of no great consequence)! Press <C>.

A smidgeon of simple animation shows a moving yellow arrow that illustrates the direction in which current is said to flow from a battery (or other DC power source), through a circuit (in this case just a resistor) and back to the battery – from +ve to –ve. Press <C> again if you wish.

Now press <E>. This time, a red blob flows from the battery's –ve terminal, through the resistor and back into +ve. This represents the way in which electrons are said to flow through a circuit, in the opposite direction to current flow.

Electrons are those mysterious electrical charges that revolve at high speed around atoms, sometimes breaking loose to provide the energy we call electricity. And that's almost as far as we go with this subject!

However, we must comment (very briefly) on the directions in which current and electrons are said to flow. They are concepts perceived by the original researchers into electrical phenomena in earlier centuries who, for reasons best known to themselves, decided that this was *The Way Things Are!* In everyday situations you're going to find yourselves in, forget the concepts! It makes life far easier if you just think of electricity (or power, or current if you wish) as flowing from +ve to –ve (where –ve is often just expressed as 0V or Ground).

Which is all we're going to say on that!

IT'S VALUABLE

Back to the values shown in the circuit diagram. If you look at the box at the top left of the screen, you will see the values for I and for R as shown in the circuit. Either of these can be changed from your keyboard. Since I is highlighted, it's the one immediately available to be changed. Again the arithmetic keys are the ones to do it, with the same step multiples that we've used in other program options.

To select R instead of I, press <R>. The resistance values can now be changed as before. Pressing the keys for any of the letters shown (V, I, R, P) highlights that letter. When the letter and value have a hash symbol (#) to the left, that value can be changed. If a hash is not present, the value is not changeable from the keyboard.

The values available for changing vary depending on which formula is highlighted. At present it is V = I x R that is selected. In other words, we want the computer to calculate the value for V when I and R have values we have given them. In this case, R = 4700Ω and I = 0·001A, and the computer states that, because of this, V = 4·7V.

The value of 4·7V is shown in the circuit diagram, and also as the answer in the Example box above the formulae. Change the values for I and R, and observe the results. Experiment by selecting other formulae.

You can change the way in which values are shown by using <X>, the scaling key. This allows, for example, V to be expressed in volts, millivolts or microvolts.

All the function keys you can use are stated on the screen.

IT'S TESTING TIME AGAIN

You've spotted the Self-test option haven't you? OK, select it!

Knowing how good your memory is, we've cleared the formulae, put some random values in the Preset Values box and now ask you to calculate an answer to the question posed where the Examples used to be. Do as the question requires.

It was too complicated to set up a points awarding scheme via the computer, so calculate your answer and then press <A> for the computer's answer to be shown. Hopefully, your answer will tally. If not, think about what you may have done wrong. The full formulae are re-displayed each time you press <A>.

To try another question, press <S> again. Once more the question is randomly selected by the computer. However, although the formula you are being tested on is fixed, you can cheat a bit if you like,

TEACH-IN 2000 – EXPERIMENTAL 3

OHM'S LAW AND RESISTANCES

by changing the values shown. It's not often that you see this option in exams!

When you've had enough, press <M> to return to the main menu. Now we suggest that you move on to this month's accompanying *Experimental* article.

NEXT MONTH

In Part 4, we shall look more closely at frequency and it's different waveforms. We shall also start looking at ways in which your computer can be used to monitor frequency and some of the waveforms.

Are you keen to have a go at some more experiments? Great, but the author's going to leave you on your own while he goes back (he says) to contemplating the answer to the Universal Theory of Everything – as fans of the *Hitch Hiker's Guide to the Galaxy* already know, rumor has it that it's 42, but it needs checking! Before he goes, though, here's what he suggests you do:

Refer back to Part 2 and revisit the circuits and experiments you did there, including the oscillator. This time, though, (as you did with Fig.3.1) add a potentiometer in series with the timing resistor and find out how easy it can be now to readily provide different values of resistance without using calculators and hordes of resistors.

You were recommended to buy a selection of preset potentiometer values, so choose various values as you wish, and just generally see what happens. You will soon discover what relationship of potentiometer to resistor values can be appropriate in different circumstances.

PRACTICING POTS

You can also try using two or more pots in series and/or parallel and see what effect the configuration might have. You may find, for example, that a high value of pot is useful for setting a rough voltage or current setting, and then a low value of pot used with it can set a more finely tuned value. The presets can be just plugged in and out of the board and connection wires added.

Some suggested configurations are shown as circuit diagrams in Fig.3.7. The equivalent breadboard arrangement for Fig.3.7a is the one you used at the beginning if this month's Tutorial, Fig.3.1. The basic circuit diagram, if you care to draw it out, will be found to be identical to Fig.2.15 in Part 2, with the potentiometer(s) inserted in the feedback path between IC1 pin 6 and resistor R1.

Also try using not only the 74HC14 Schmitt trigger inverter that you ended up using for last month's oscillator, but also the original 74HC04.

A further suggestion is to gain experience of rotary linear and logarithmic control potentiometers. Use crocodile-clipped leads to make the connections. Fig.3.8 shows an example of where the control pot can be connected (note that the preset has been removed in this example).

APPLYING OHM'S LAW

Something else to keep you amused (and reinforce your knowledge) is to experiment with Ohm's Law. This will also introduce you to using your multimeter for measuring current.

First, check your multimeter's manual to see which sockets you need to use for current measurement. One is likely to be different from that used for voltage and resistance measurements.

Now for a further caution (yes, they will keep cropping up from time to time). Whenever you use a multimeter to measure an unknown current, always set it to the highest range (e.g. 10 amps – 10A) before connecting it into the circuit. If a low range were to be selected when in fact a large current is going to flow through the meter, you could seriously damage the meter.

This is especially true with analog meters (which sooner or later you'll probably find yourself using). They have a moving pointer that rotates across a scale. If too low a range is set, the pointer could slam hard up against the end-stop, possibly causing mechanical damage, and perhaps even electrical damage to the rest of the meter.

Always play it safe with meter ranges – select a higher one than you think you need, then you can work downwards once the connections are made and you discover what range is best suited to the reading being taken.

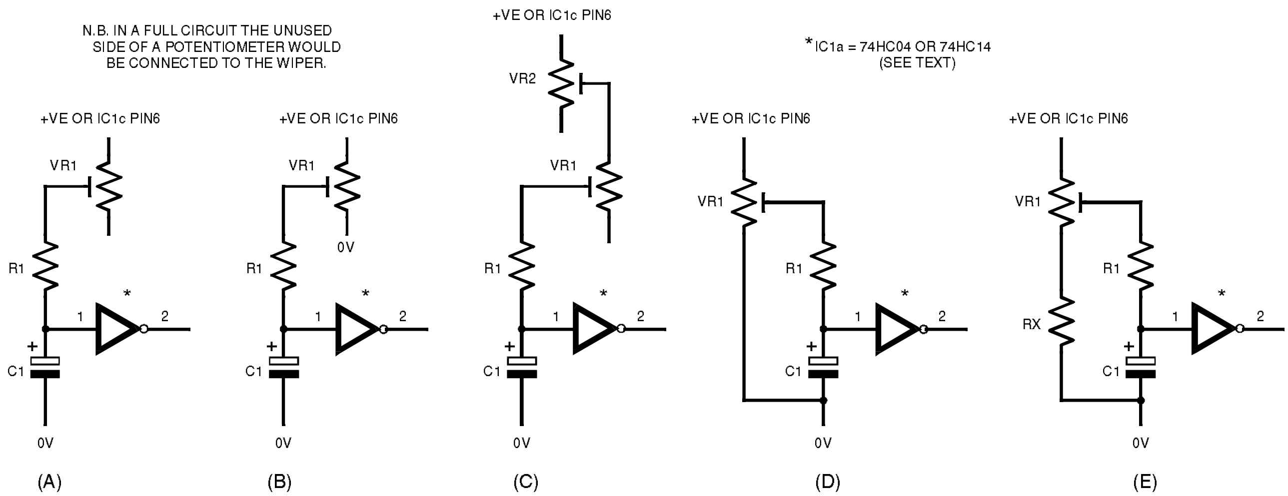


Fig.3.7. Some suggested configurations of pots for use in the breadboard experiments in Fig.3.1 and Fig.3.8.

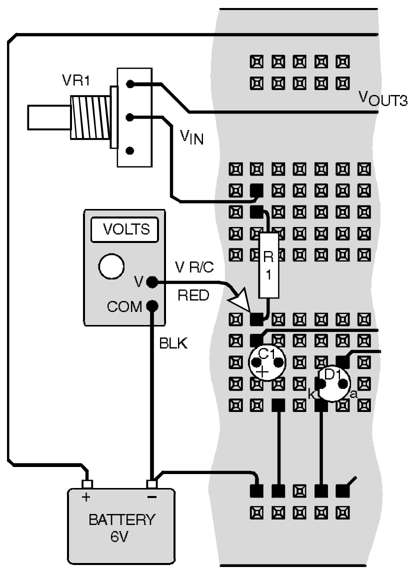


Fig.3.8. Using a control pot in place of a preset in the breadboard experiments.

CURRENT AFFAIRS

So, with your meter set to the highest DC amps range it has, start making some current measurements along the following lines:

Take a 10kΩ resistor, and using the breadboard arrangement shown in Fig.3.9, connect it to the power supply via your meter. Read off the current flowing through this

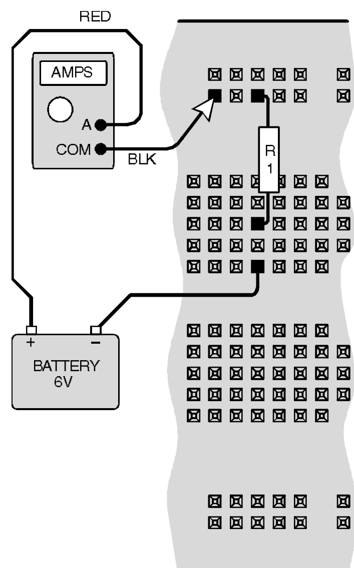


Fig.3.9. Measuring current flow through a resistor.

simple circuit. Does it correspond with the current value you calculate using Ohm's Law? It should if the resistor is truly a 10kΩ component and the battery is truly supplying exactly 6V.

Chances are, of course, that neither is true, so your calculated result will be inaccurate. So what have you discovered? You have discovered that before you take a reading of one factor and relate it to others in a calculation, you should make sure of your facts!

One fact you did not check first was the exact voltage that exists across the resistor. The other fact is that you did not measure the resistor's precise value.

However, you do not need to measure both resistance and voltage in order to make sense of the current reading. You only need one fact to be established beyond a shadow of reasonable

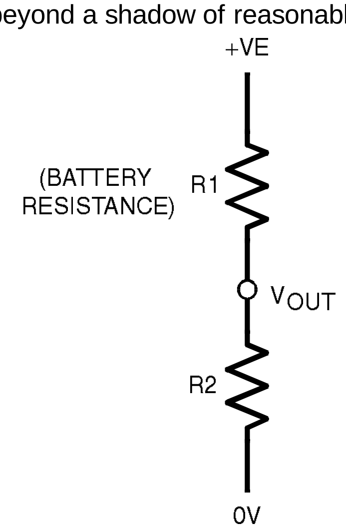


Fig.3.10. Since a battery has internal resistance, its output voltage depends on the load (R2) it is powering.

doubt, either the voltage, or the resistance. Knowing one or the other, and the current reading shown by your meter, you can calculate what the other (unknown) value will be.

Here and now, let's assume the resistance value is unknown, and establish the true voltage value. Disconnect your meter and set it to a suitable voltage range. Now you can measure the voltage supplied by the battery, or can you? In fact the answer is … No, not at the moment!

BATTERY RESISTANCE

What you are likely to be unaware of right now is that the battery itself has an internal resistance. Because of this resistance, the voltage actually available for use from the battery depends on the resistance across which the battery is connected.

It's like having two resistors in series with a known voltage across them. The voltage at the resistor junction will be less than that across them both.

So too with the battery, it is one of the resistors in the chain (the one nearest to the positive supply – R1 in Fig.3.10) whilst the circuit itself is the second resistor (R2).

Consequently, if you measure the voltage on the battery you will find a higher voltage present when the battery is not connected to a circuit than you will if it is supplying power to one.

Elementary My Dear Watson, once you know the facts.

What you need to do now, is to connect the battery to the resistor, and then take a reading of the battery's voltage. Now you're getting somewhere!

Knowing the current reading you made previously, you can relate it to the voltage reading just taken, and from them both discover the exact resistance of the simple circuit.

Why not just measure the resistor on the meter's resistance range? Yes, we could, in this particular case. But suppose that you have a complex circuit with all sorts of components, both active and passive, and you want to know the total resistance of that circuit?

You may not be able to directly measure the resistance itself, either because you simply cannot get your meter probes into the right place, or because some of the components will have different resistance values depending on whether the power is turned on or off.

It is, of course, not possible (or permissible) to connect a multimeter set on a resistance range across a circuit that has power on it. Severe disruption could occur to both the meter and the circuit should you do so. You certainly won't get a meaningful resistance value reading in this way!

But, won't the meter's own resistance affect the battery voltage when placed in the circuit to take current measurements? A very good point! Yes, it will, but the resistance is so very, very small that it can be ignored in this instance (unlike when voltages at more significantly resistive junctions are being measured, when the meter's resistance can affect the reading – as we discussed last month).

As you can see, we've learned quite a lot from that single resistor, haven't we?

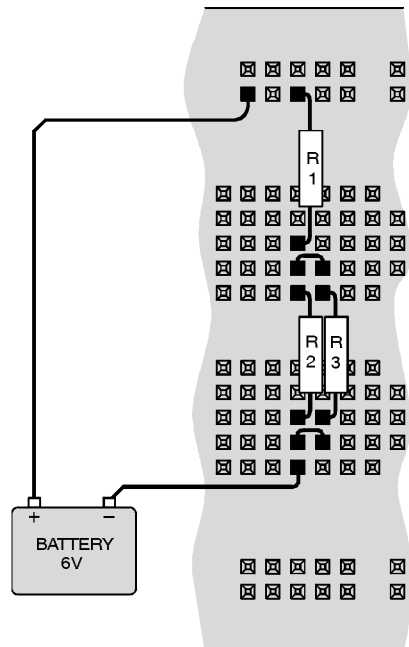


Fig.3.11. Breadboard layout for a slightly tricky exercise!

ANOTHER SUGGESTION

Ask a friend to select two resistors at random (without you seeing them), cover their color codes with opaque sticky tape (black insulating tape, for example). Then you can plug them into the breadboard as a series across the power supply (battery). Your task is to find out the value of each resistor, without measuring it on the meter's resistance ranges!

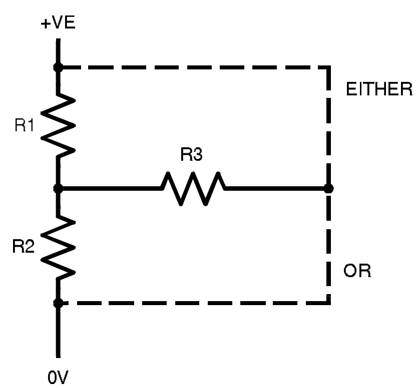


Fig.3.12. Circuit alternatives for another exercise.

Knowing Ohm's Law and the rule that applies to the voltage at the junction of two resistors in series, you should have no difficulty in figuring out the answers! (You may disconnect anything in order to insert the meter for current measurements, but do not change the basic order of the components.)

Now for a slightly trickier problem. Ask your friend to pass you three resistors selected at random and with their color codes taped over. Place them (in any order) into your breadboard as shown in Fig.3.11, R1 and R2 in series, with R3 in parallel with R2. Now find out all three values, without cheating or rearranging the circuit! (Again you may insert the meter wherever you wish, but don't use the Ohm's range.)

Next, suppose your meter's current and resistance ranges have packed up for some obscure reason. You know the voltage of the power supply, and you need to know the current flowing through two unknown resistors in series (R1 and R2 again, but of different values to the last experiment) across the power supply.

Indeed, once more let your friend be the one who selects those obscured value resistors and you place them in the circuit.

You now have the whole range of your stock of resistors available, with their value codes in full view. Using any value of your choice, connect that resistor (call it R3) to the junction of R1/R2.

By connecting the other end of the resistor to either power line of your choice (see Fig.3.12), find out the values of the two unknown resistors, and the total current flowing through

Photo 3.4. A handful of ORP12 light-dependent resistors (LDRs)

them. As a hint, it's the resistors in series and in parallel rules that are needed, plus Ohm's Law.

Now, before we move on to this month's final enlightenment, how much power is being used by R1 and R2, both separately, and in total?

The calculations needed for all the above problems can be done using the relevant sections of the computer program, although the basic concept of how you set about finding the answers is up to you to figure out!

SPEED OF LIGHT

Finally (for this time), have a bit of light entertainment while you're pining for next month's *Teach-In*.

We spoke of LDRs (light dependent resistors) in this month's Tutorial. As we mentioned, one such type is the ORP12 (and NORP12), see Photo 3.4. Whichever of the two was supplied to you in your bag of parts – connect it into the oscillator circuit of Fig.3.1 in series with resistor R1, in place of VR1. Point the LDR's face upwards from the board.

In fact, it does not matter which side of R1 you place the LDR, the total resistance is the same in whichever order you have a series of resistors. Nor does it matter which way round the LDR's pins are connected; as with "ordinary" resistors, it is a non-polarized device.

Make R1 about 10kΩ. The 74HC14 Schmitt Trigger should be used as the inverter for this experiment.

In a fairly well-lit room, connect power to the oscillator. The LEDs should flash at a fairly high, but still discernable, rate. If the rate is too fast, amend the value of the capacitor.

Now pass your hand slowly, very slowly, across the board so that a shadow begins to cover the LDR. The rate at which the LEDs flash should progressively decrease, and then speed up again as the shadow moves away.

What you are demonstrating is how the LDR's resistance value changes depending on the amount of light that reaches it. If you actually cover the LDR with a finger, you might even stop the oscillator.

MORE LDR TESTS

Also, come back to the timing circuit in Part 2 in which we first suggested using a light-emitting diode (LED) with an inverter gate (Fig.2.11). Place the LDR in series with R1 in that circuit, and alternately connect up to the +ve and –ve connections on the battery. Note the rate at which the LED turns on or off, as appropriate, depending on the amount of light falling on the LDR.

You could also take the LDR on its own and measure the resistance it has under different light levels, from near full darkness (just enough light

to read your meter) to full blazing sunlight.

For any fixed level of light at a given distance from the LDR, see if you can plot a graph of the resistance according to the amount of the LDR's face that is obscured from the light. Strips of opaque insulating tape placed on the LDR face will help in this. You should be able to get at least four readings.

Do your observations suggest any possible applications to which you could put such timing and oscillating circuits? We shall return to look at some ideas another time.

Be with you again in a month – till then Millennial Greetings!

Go to next section

TINA PRO REVIEW

Mike Tooley BA

DesignSoft's TINA PRO is the latest version of two extremely popular programs; TINA for Windows and TINA Plus for Windows. Founded in 1992, DesignSoft is based in Budapest, Hungary, and the company's stated mission is to develop high-tech engineering and educational software including electronics, physics, architectural design, multimedia, and 3D-graphics. DesignSoft currently has distributors in 22 countries including the well-known UK electronics design software house, Quickroute Systems. DesignSoft describes TINA PRO as a "Complete Electronics Lab for Windows". Mike Tooley sets out to investigate this claim.

TINA PRO is a powerful yet affordable software package for designing, simulating, and analyzing analog, digital and mixed (analog/digital) electronic circuits. Results of circuit analysis can be displayed in various ways, including displays produced by TINA PRO's virtual instruments. A comprehensive range of desktop publishing tools are available with which you can easily produce professional-looking reports and publications. Cutting and pasting TINA PRO's output into a Windows application program (such as Microsoft Word or Microsoft Publisher) is also quick and simple.

TINA PRO is available in several different versions, including a trial/demo version containing a selection of self-demonstrating examples (but with save and print disabled), a single user version (licensed for use on a single computer), and a network version suitable for use with Novell Netware (version 3.12 or later) and Windows NT (version 4.0 or later).

It also includes unique tools for testing students' knowledge, monitoring progress, and introducing troubleshooting techniques. With optional hardware it can be used to test real circuits for comparison with the results obtained from simulation. Teachers and lecturers will be delighted with TINA PRO's training and examination modes that allow the package to be used as a powerful tool in the classroom or as a standalone training aid in the school/college open-learning center.

DesignSoft has placed TINA PRO in the middle of the market, between Electronics Workbench EDA (at the professional end of the market) and Crocodile Clips (at the student end of the market). Despite its simplicity – the program really is easy to learn and use – TINA PRO is extremely powerful and should easily satisfy the requirements of the hobbyist and enthusiast as well as the professional user wishing to carry out in-depth circuit analysis.

SYSTEM REQUIREMENTS

TINA PRO is a 32-bit application that will run well on virtually any modern Windows-compatible PC. However, for the benefit of those readers who may be unsure of whether or not their hardware will support TINA PRO, the basic requirements are:

- o) Microsoft Windows 95/98 (or Windows NT 4.0, or later).
- o) IBM PC/*AT* compatible computer with a '486 (or later) processor.
- o) 16 MB RAM.
- o) 20 MB hard disk space.
- o) Mouse (or equivalent pointing device).

INSTALLATION

Installation is quite straightforward and TINA PRO's CD-ROM installer will auto run on a system configured for autorunning applications from CDs placed in the CD-ROM drive. Once started, the set-up program will display a menu offering users the choice of:

- o) Installing Internet Explorer.
- o) Installing TINA PRO.
- o) Viewing a tutorial covering the most important features of the program.
- o) Obtaining information on upgrading and ordering.

A full TINA PRO installation

requires 22,189 KB of space on a local hard disk drive. With modern multi-GB hard drives this should not place too many demands on your system!

Having selected the option to install TINA PRO, you are next offered the choice of either American (ANSI) or European symbols. Installation takes just a few seconds, thereafter you are presented with a message that informs you that the "Trial Installation" is valid for "15 runs". In common with most well-behaved applications these days, TINA PRO provides its own uninstaller. This program cleans up the Windows system files and removes all of the TINA PRO files without removing any user-created data files.

For the educational user, TINA PRO may be installed on a network (Novell 3.x, Novell 4.x or Windows NT) and configured for multiple user access. After running the network set-up utility, users will be able to run TINA simultaneously, just as though each workstation had a single user version installed.

Unfortunately, TINA PRO registration is a little cumbersome. Program branding not only involves a "Registration Code" but it also requires a "Site Code", and a "Site Key" (supplied as part of the registration process). Doubtless there are good reasons for this somewhat complicated process.

FEATURES

TINA PRO provides more than 10,000 built in components. Component selection is based on a simple "Component Bar" with tabs that are used to arrange components in manageable groups. The program also provides more than 1,000 manufacturer made components in Spice sub-circuit format. Compared with earlier TINA versions, a number of new component models, including nonlinear coils, transformers, relays, Darlington transistors, opto-couplers, voltage regulators, fuses, comparators, and CMOS logic ICs, are provided. Other useful features include:

- o) Analog, digital, and mixed (analog/digital) mode simulation.
- o) Powerful editing tools (schematic, netlist, text, equation, and waveform editors)
- o) Customizable presentations of Bode plots, Nyquist diagrams, transient responses, or use of virtual instruments in order to produce conventional instrument displays.
- o) Spice library manager.
- o) Symbolic analysis (results appear as closed form expressions).
- o) Fourier analysis (Fourier spectrum, Fourier series, and distortion).
- o) Noise analysis (including noise spectrum and signal-to-noise ratio).
- o) Tolerance analysis (Monte Carlo and worst-case scenario).
- o) HTML-based component help.
- o) Sub-circuits, which may include both spice macros or schematics.
- o) Schematic symbol editor for creating custom sub-circuit components.
- o) Average and RMS value determination for arbitrary periodic waveforms.

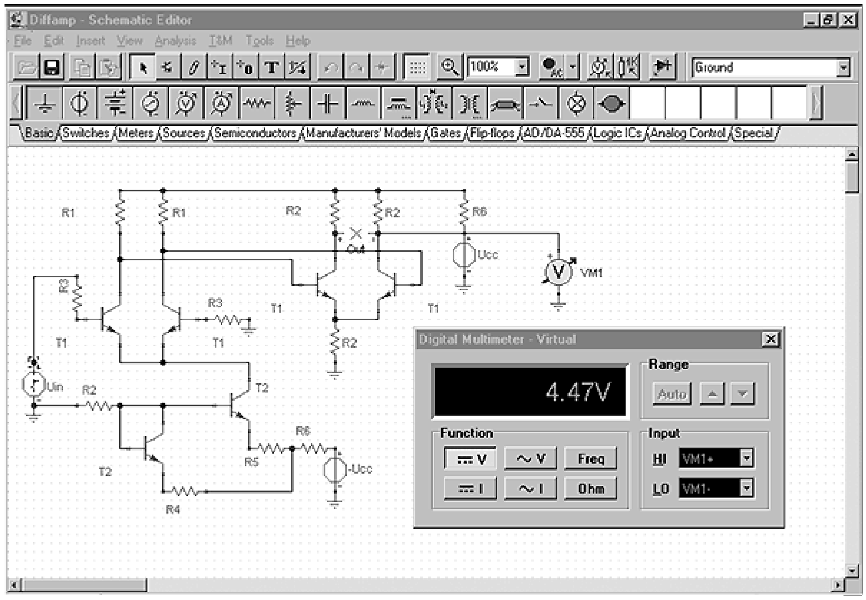


Fig.1. The TINA PRO screen.

TINA PRO SCREEN

The TINA PRO screen format is shown in Fig.1. The screen comprises a conventional Windows menu bar that provides access to all of the main program functions, such as File, Edit, Insert, View, Analysis, etc. Below this is a toolbar that provides access to some of the most commonly

used editing features, such as cut, paste, and zoom.

The component bar is located beneath the toolbar. The component bar provides access to the extensive library of components that is supported by TINA PRO. Components are arranged in groups, named by the tabs on the Component Bar. Once a particular group has been selected, the available components appear as a row of symbols immediately above the component tabs.

When you click on a particular component in the toolbar (and release the mouse button), the cursor changes to show the currently selected component. The component can be moved anywhere within the circuit drawing area of the screen. The component can then be rotated (by pressing the + and – keys) or mirrored (using the * key). Once you have selected the position and orientation for the component you can simply press the left mouse button to lock the symbol in place.

The Task bar appears at the bottom of the screen and provides rapid access to the various tools or test/measuring instruments currently in use. Each tool or instrument operates in its own window and

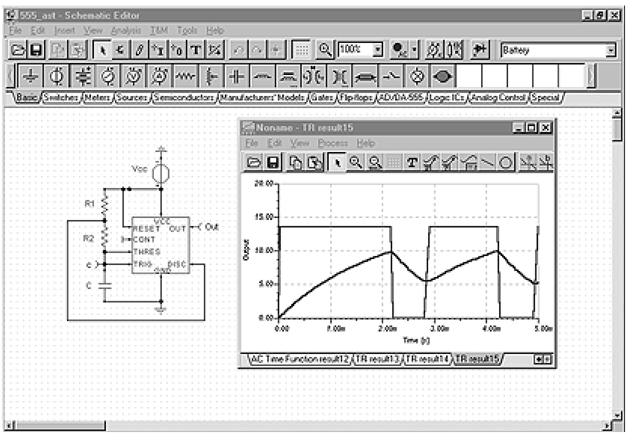


Fig.2. Using TINA PRO to analyze the operation of a simple astable oscillator based on a 555 timer.

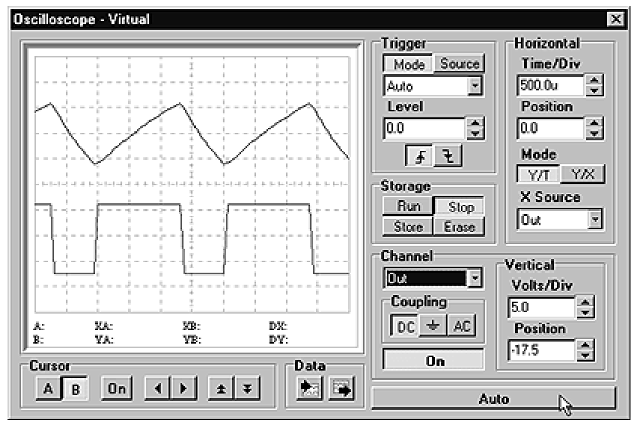


Fig.3. Using TINA PRO's virtual oscilloscope to view the output waveforms produced by the astable oscillator in Fig.2.

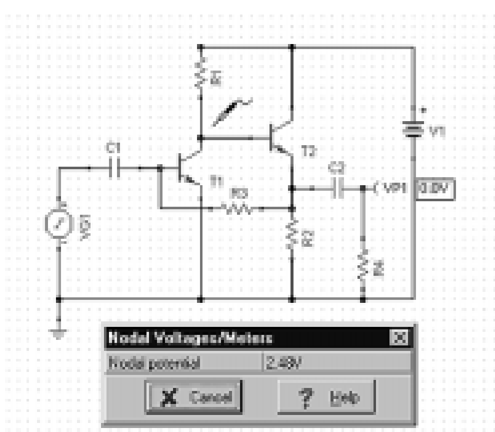


Fig.4. The first attempt using TINA PRO involved “building” and testing this simple two-stage amplifier. Having assembled the components in the schematic window, TINA PRO's nodal voltage analysis tool is being used to check the bias conditions (note the test probe at the collector of TR1).

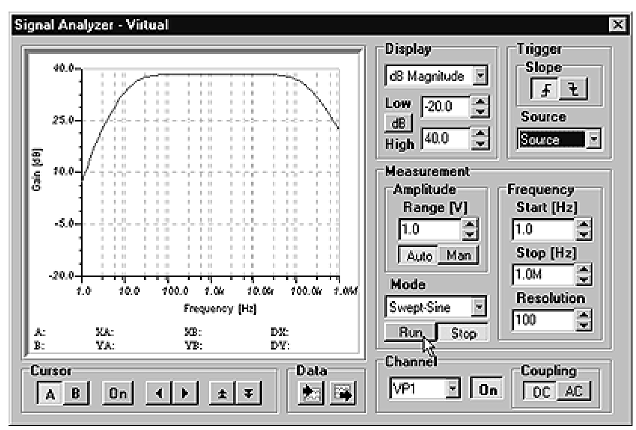


Fig.5. Frequency response of the two stage amplifier using TINA PRO's virtual frequency analyzer (the amplifier's upper cut-off frequency has been limited to about 100kHz by applying some HF negative feedback).

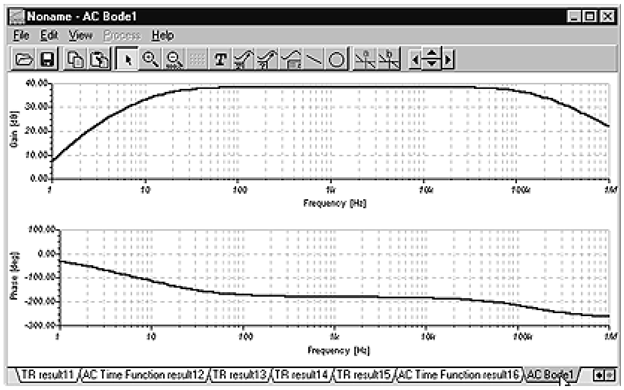


Fig.6. An alternative to using one of TINA PRO's virtual instruments is that of using one of the built-in analysis tools. This shows the alternative gain and phase versus frequency display (without the controls and adjustments that would be present with the signal analyzer virtual instruments).

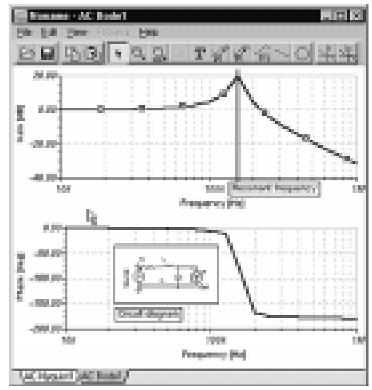


Fig.7. The graphic displays produced by TINA PRO can be enhanced and customized by the user. Here some captions, markers and a circuit diagram have been added to a basic Bode plot that shows the gain and phase response of a simple L-C-R series resonant circuit.

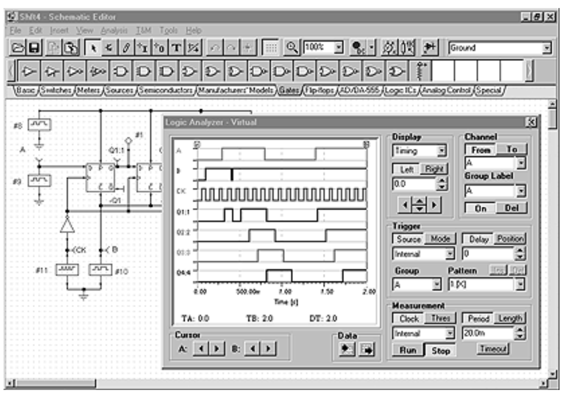


Fig.8. TINA PRO is equally at home analyzing digital circuits. Here we are displaying the output of a four-stage shift register using TINA PRO's logic analyzer virtual instrument.

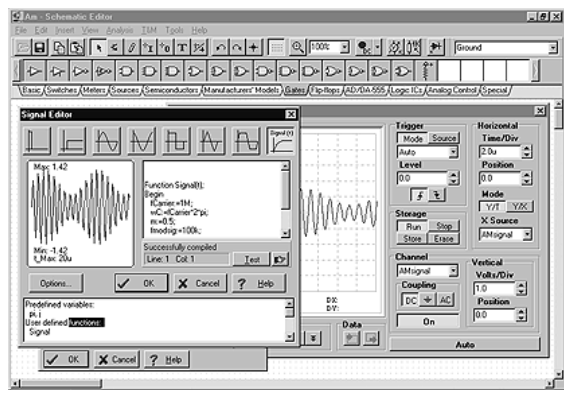


Fig.9. TINA PRO has many advanced features, including signal and equation editors. This screen shows how the signal editor can be programmed to produce an amplitude modulated signal (part of the resulting signal appears in the virtual oscilloscope window

can be made active by clicking on the respective Task bar button. Finally, TINA PRO provides a single line of help text at the bottom edge of the screen.

INTERACTIVE MODE

The ultimate test of a circuit simulation is to try it in a "real life" situation using interactive controls (such as keypads and switches) whilst watching displays and other indicators. Fortunately, TINA PRO provides you with an interactive mode that will allow you to do just this!

Not only can you play with the controls but you can also change component values and even add or delete components while the analysis is in progress.

SUB-CIRCUITS AND MACROS

As with other SPICE programs, TINA PRO allows you to simplify a complex circuit schematic by turning portions of it into a sub-circuit. In addition, you can create new TINA PRO components from any SPICE sub-circuit, whether created by yourself, downloaded from the Internet, or obtained from a manufacturer or component supplier's CD. A typical example of where you might wish to use a sub-circuit is that of a half-adder, replacing the five discrete gates with just one

"black box" subsystem. Once the subsystem has been created (and tested) it can be used over and over again.

TINA IN THE CLASSROOM

TINA has two special modes for educational purposes. In examination mode, the student has to solve a series of problems (a problem set) either by traditional pencil-and-paper methods or by using the TINA Interpreter and analysis functions. When the student finds the answer, the program sends it immediately to the teacher's machine, where it is promptly displayed by the TSuper supervision utility. Operation is similar in training mode, except that TINA gives the student feedback about the correctness of his or her answer. In training mode, the student may turn to the Advisor to get help prepared by the teacher.

TINA PRO can be set into one of the special educational modes by the use of a command line switch, the general format of which is:

TINA [MODE SWITCH] [FILENAME]

where [mode switch] is either /EXAM or /TRAIN, and the [filename] is the relative path and filename (with the optional .EXA extension) of the problem set descriptor file. This file must have been prepared using the TTask program, and should give the names of the problems in the set, along with their train/exam options. This path is always relative to the TINA home directory; that is, the descriptor file must reside in the TINA directory (where TINA was installed) or one of its subdirectories. If this is all beginning to sound a little complex, here's an example:

Assume that you have a descriptor file TEST_B.EXA that resides in the TEST subdirectory, the program can be started with the commands:

TINA /EXAM TEST\TEST_B

or

TINA /TRAIN TEST\TEST_B

The TINA PRO installation program actually provides you with two icons in the TINA program group that can be used to start the program in training/ examination mode. You then only need to click on the required icon in order to start the program in either training or examination mode. TINA will then prompt you for the name of the descriptor file. When the program is started, it will request the student's name. The student can then select a problem using the Tasks List on the Examination/Training Panel.

The Examination/Training Panel appears automatically when TINA is started in examination or training mode. The current mode (Training or Examination) is displayed at the top of the panel. Beneath the mode display is the total accumulated time display. This starts counting when the student selects the first task.

ADVISOR

An Advisor Panel gives access to the hints prepared by the teacher. Some advice items carry a penalty, in which case the student will be warned that a penalty applies. The Current Task panel allows the student to prepare and submit a solution to the problem. The contents of this panel are dependent on the type of the problem.

The Interpreter standard button will launch the built-in TINA PRO interpreter. The Submit standard button will validate the solution and file it in the student records.

It is important to note that TINA PRO will only accept as correct those solutions that are formally valid; e.g. in DC problems both the numerical value and the units must be correct. If the answer is a numerical/symbolic expression, the correct units must also be given. When using the training mode, TINA will either confirm the answer or tell the student how the solution is incorrect (e.g. missing units, syntax problems, etc.).

Doubtless this will be music in the ears for long suffering teachers and lecturers who, like me, find that students are all too often hazy about the units that they are working in or are simply too lazy to state the answer in full!

SUPPLEMENTARY HARDWARE

DesignSoft has developed a variety of external hardware modules that can be attached to a PC for use with TINA PRO. This includes:

- o) TINALab, a data acquisition card with multimeter, oscilloscope, and signal generator functions.
- o) ExtBox, an experimenter box that allows users to assemble prototype circuits as well as making measurements on up to 16 external modules.
- o) FaultGen, an expansion

card (for use in conjunction with the experimenter box) that allows faults to be placed in tested circuits.

o) DigiCard, an expansion card (for use in conjunction with the experimenter box) that facilitates measurements on digital circuits .

o) Experiment modules, a series of modules that can be used to demonstrate the operation of basic electronic circuits. The modules are automatically recognized and displayed when they are connected to the experiment box.

IMPROVING THE OUTPUT

Having designed and analyzed your circuit, you will, at some point, probably want to disseminate your results to others in the form of a paper or technical article. TINA PRO will help you to do this – at least by providing you with all of the graphical content – in the form of Bode plots, Nyquist diagrams, transient responses, digital waveforms, etc. You can create, edit and print documents from within TINA PRO or cut and paste the results into another Windows application using the Windows clipboard.

A particularly useful feature is that TINA PRO's graphics editing facilities allow you to add your own information to the results of a circuit analysis. It makes it easy to add markers, special annotation, and circuit schematics to the results of any circuit analysis. This facility is a real boon for students as it can save hours of graph plotting, drawing and sketching.

VIRTUAL INSTRUMENTS

TINA PRO provides you with a Function Generator, Digital Multimeter, Frequency Analyzer, Logic Analyzer and a dual-channel Oscilloscope. These instruments provide the same displays and control as found on real instruments and will help you make measurements in just the same way as you would in a real laboratory.

As an added bonus, if you have TINA PRO's supplementary hardware, the program will allow you to switch to "Real Measurement" mode. This facility lets you work with the same on-screen instruments and settings when making real measurements on a real circuit.

HELP!

The "Quick Start" manual comprises around 70 pages in A5 spiral bound format. The manual is divided into four sections; Welcome, Introduction, Installation and Start-Up, and Getting Started. Of these, the last section is by far the largest (comprising 43 pages). On its own, the manual is not particularly extensive. However, TINA PRO's help system provides a wealth of reference information (including a comprehensive description of the SPICE models). One unfortunate omission from the manual is the lack of an index.

IN USE

In use, I found TINA PRO extremely intuitive. My first task was to "build" and test a simple two-stage amplifier. This was accomplished quickly and easily and without having to refer to either the manual or the help text. Next, I put TINA PRO to work solving some network problems that form the basis of assignments carried out by my HND students. Once again, TINA PRO excelled at the task, delivering not only the response curves required but also formulae required to produce the transient response for each circuit.

TINA PRO incorporates a number of features that make it a real pleasure to use. These include the orthogonal wiring tool, the multiple undo facility, and the automatic component numbering. The various output displays produced by the program are excellent, as are the virtual instruments.

There are two features that I would like to see in the next version of TINA PRO. The first is a menu option that will allow users to open a selection of the most recently used files *(Since this review was written we have been advised by Quickroute Systems that this request has been implemented. Users can now open a selection of the most recently used files – Ed)* whilst the second is a facility that will allow me to print the virtual instrument displays and settings (I use this facility regularly in Electronics Workbench to keep a record of circuit performance as I make changes to circuit parameters, component values, etc). That said, I have very few other concerns and niggles!

IN CONCLUSION

TINA PRO is packed with features, simple to use and represents really good value. So, if you are thinking of moving up to a Windows SPICE package (or are planning to upgrade your current SPICE software) you should take a

serious look at DesignSoft's latest offering – it can be highly recommended!

DesignSoft can be contacted at: **www.designsoftware.com**

The TINA website is at: **www.tina.com**

Note that a demonstration version of TINA PRO can be downloaded from this site. The site also features a Students' Forum and a downloadable "Student Contest" with a chance to win a free upgrade to the full version of TINA.

In the UK, TINA PRO is available from: Quickroute Systems (Dept EPE), Regent House, Heaton Lane, Stockport SK4 1BS, UK. Tel: +44 (0) 161-476-0202, Fax: +44 (0) 161-476-0505. (Please mention this review when contacting Quickroute.)

PRICES

There is a wide range of TINA PRO software available, together with various different site licenses for those that need them (prices on request from Quickroute Systems).

TINA PRO Basic – a cut down starter version suitable for hobbyists and students (particularly helpful for students who have access to a full version at college etc): 57.58 UK Pounds (including VAT and shipping and handling).

TINA PRO Educational – includes full Teacher Pack: 204.45 UK Pounds (including VAT and shipping and handling).

TINA PRO Industrial Classic Edition – similar to the full Industrial Edition but without the SPICE library, a symbol designer, or the ability to form component models from manufacturers' data. 204.45 UK Pounds (including VAT and shipping and handling).

TINA PRO Industrial Edition – the full version with all the options. 363.08 UK Pounds (including VAT and shipping and handling).

Further information on the various versions is available from Quickroute Systems, also see their web site at: **www.quickroute.co.uk**

Go to next section

Practically Speaking

Robert Penfold looks at the Techniques of Actually Doing it!

This series of articles is aimed primarily at complete beginners, but this month we move on slightly to consider the subject of transformers and mains powered projects. No excuses are given for pointing out yet again that mains powered projects, or indeed any projects that involve direct connection to the mains supply, are ***unsuitable*** for beginners. ***The mains supply is potentially lethal and has to be treated as such by those who deal with it.***

Until they have gained sufficient experience to tackle mains oriented projects, beginners should settle for building battery-powered gadgets. If you make a mistake with a project powered from a PP3 battery it is unlikely that anything will be damaged, and you should certainly be in no real danger.

A similar mistake with a mains powered project would probably cause a lot of expensive damage and could be extremely dangerous. ***When dealing with a mains powered project you have to proceed as if your life depended on it, because it does!***

ADAPTABLE

Beginners should not overlook that very useful invention, the battery eliminator (mains adapter). The regulated types mostly have accurate and well-smoothed outputs that can be used to power projects that would be uneconomic to operate from batteries. (Most components suppliers carry stocks.)

A unit of this type should comply with the commercial safety regulations, and provide a safe means of obtaining mains power for a wide range of circuits. A few projects have specialized supply requirements that no battery eliminator can meet, but the vast majority of projects can be powered in this way.

Unless you know what you are doing, it is advisable not to use non-regulated eliminators. In general these have large amounts of mains "hum" on their outputs and the actual output potential varies considerably with variations in loading. When lightly loaded the output can easily be more than 50 percent higher than the nominal output voltage, which could be sufficient to damage some circuits.

DOWN TO EARTH

When copying a battery powered project you are largely free to "do your own thing", but with a project that connects to the mains supply you must be more cautious. Everything must be done in a manner that will be completely safe.

This does not mean that you have to produce an exact clone of the author's original, but everything must be done in a way that satisfies some basic rules of safety. For instance, any exposed metalwork **must be reliably earthed to the mains Earth lead**.

In practice, this invariably means using a case that is largely or entirely constructed from *metal*. With the case earthed, any metal parts mounted on it will also be earthed. In the past, a solder tag mounted on one of the mains transformer's mounting bolts has been used as the earthing point on the case, but it is apparently considered safer to have a separate mounting bolt for the earthing point – see Fig.1.

Another important point about the case is that it should be a type that cannot be opened easily. In other words, a screwdriver or other tool should be required in order to open the case so that there is no easy way of gaining access to the dangerous mains wiring. An enclosure that has some form of clip-on lid should ***not*** be used, as this would make it too easy for young hands to open the case.

COVER UP

As a second line of defense, it is advisable to insulate any connections that carry the mains supply. There are matching insulators, known as "boots", available for some components (also shown in Fig.1). These make it easy to completely and reliably insulate all the connections to a component. Unfortunately, these "boots" are not as widely available as they should be, and are not available for all components that could be used to carry the mains supply.

However, in most cases it is possible to insulate the tags and the connections to them using large diameter PVC sleeving. In order to accommodate the tag, the wire, and the connection, an inside diameter of around 4mm to 6mm is usually required.

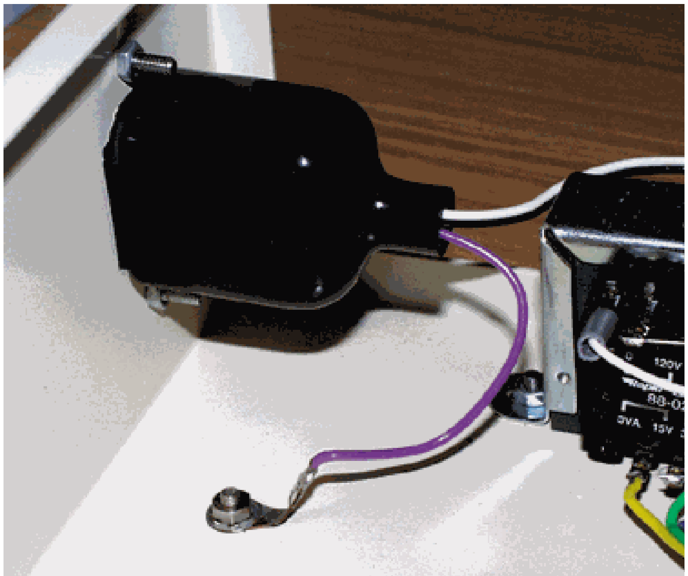


Fig.1. A solder tag provides an Earthing point on the base of the metal case. The IEC inlet is comprehensively insulated by a matching insulating "boot".

TRIP WIRE

It is possible to connect the mains lead direct to the on/off switch and earth tag, and this is again a method that has been used extensively in the past. However, it does have the disadvantage of being a bit dangerous if someone should trip over the cable. The person doing the tripping over could injure themselves, and the project could be left with a damaged cable and exposed mains wiring.

A better, if somewhat more expensive option, is to use a standard IEC connector at the rear of the unit, and to connect this to the on/off switch and earth tag. If anyone should accidentally kick the cable it should simply pull free from the rear of the project with no harm done. The IEC connector takes a standard mains lead of the type used with PCs and many other electrical and electronic gadgets.

For the ultra-safe approach you can use an IEC connector that has an integral on/off switch. There is a slight drawback in this method in that it means having the on/off switch inconveniently located at the rear of the project.

TRANSFORMERS

(Note that these discussions are largely based on the 230-volt AC supply found in the UK.) The mains transformer in a modern project performs two functions. One is to step-down the 230-volt AC supply to one that is more suitable for modern low voltage circuits. The other is to provide isolation from the mains supply.

The mains supply connects to the *primary* winding of the transformer, and this produces a low voltage signal in the secondary winding, but there is *no direct connection* between the primary and secondary windings.

Provided you use a modern transformer that conforms to the current safety regulations, there will be comprehensive insulation between the primary and secondary windings, and there will be no significant danger in touching any wiring in the secondary circuit of the transformer. Even if a fault should occur in the insulation, with the case and one supply rail earthed there should be little danger anyway.

HAVING TWINS

Modern mains transformers tend to cause a certain amount of confusion as they mostly have "twin" secondary windings, and sometimes have two primary windings as well. In the past there were sometimes two 230V or 240V primary windings that had to be connected in *parallel* for operation on the UK mains supply – see Fig.3a.

On the face of it there is no point in having two 230V or 240V windings since there would seem to be no 460V or 480V mains supplies that could use the alternative method of series connection. This type of transformer seems to have died out, but there could still be some in circulation.

The more common form of twin primary winding has two 115V or 120V windings. These can be used in series for operation on the 230V UK mains supply, or in parallel for use with some continental or USA supplies that operate at about 115V.

For operation on the UK mains, it is essential to connect these transformers in the manner shown in Fig.3b. The alternative methods of series connection (with the two "0" or "115" tags connected together) will give no significant output from the secondary winding.

Fig.2. The mains transformer at the bottom has twin secondary windings while the one at the top has twin primary windings as well.

Things are worse with the use of parallel connection, which will give an excessive primary current and double the expected secondary voltage. In addition to the likely cost of replacing damaged components, this could also be very dangerous.

SECONDARY EDUCATION

It is probably on the secondary winding side of things that mains transformers produce most problems. The reason that so many of these components have twin secondary windings is that it enables one transformer to mimic three different types of transformer.

As an example we will consider the three ways in which a transformer having twin 12V 0·5A secondary windings can be used. If the two windings are connected in series, as in Fig.4a, the output voltages are added together to give what is effectively a single 24-volt secondary. The current rating remains at 0·5A.

Parallel connection, as in Fig.4b, gives a 12V output, but the current rating is doubled to 1A. It has to be pointed out here that parallel connection is only usable with transformers that are specifically designed for use in this manner.

This mode of operation requires the two secondary windings to be very accurately matched, since any imbalance could result in one winding forcing a very large current through the other winding. Do not use this method unless the retailer's or manufacturer's literature specifically states that a transformer can be used with parallel connection.

POWER POINTS

Power supply circuits that use two rectifiers to provide full-wave rectification require a center-tapped secondary winding. The center-tap goes to the earth rail and is labeled "0V" while the other two outputs drive the rectifiers and are labeled something like "12V". Twin secondary windings can be used with this type of supply circuit, but many constructors run into difficulties because they do things in the obvious way.

With our example transformer, simply connecting the two "0V" tags together appears to give the required 12V-0V-12V output. In reality this gives two windings operating in-phase, whereas it is out-of-phase windings that are needed.

In other words, the two windings should provide power to the supply circuit on alternate half cycles, but they will actually supply power on the same half cycles. This results in no output on one set of half cycles, and what is really just a simple half-wave power supply.

The circuit may actually seem to work after a fashion, but with what is likely to be a great deal of mains "hum" on the output. The output voltage might also be inadequate.

The correct method of connection for center-tapped operation is shown in Fig.4c. This is basically just ordinary series operation, but with the point where the two windings are joined now used as the center-tap. Although this method of connection may look nonsensical, it is quite definitely the right way of doing things.

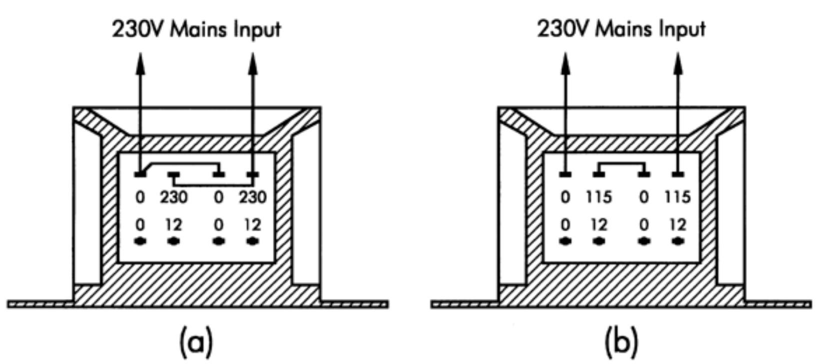


Fig.3. (a) Twin 230V primary windings are connected in parallel, while twin 115V windings (b) are used in series for the UK mains supply.

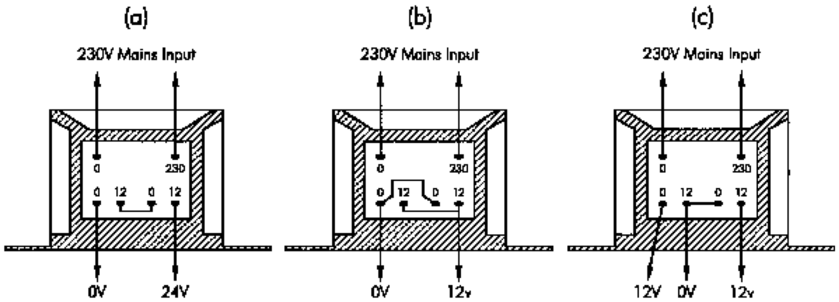


Fig.4. The three possible ways of using the twin secondary windings of the mains transformer: (a) series operation; (b) parallel operation; (c) center-tapped operation.

FINALLY

When dealing with battery powered projects many constructors keep the amount of checking to a minimum. This is a bit dubious even with battery powered circuits but is definitely not acceptable with mains powered projects. The mains wiring is usually very simple, but mistakes could cause costly damage and could also be very dangerous.

Always carefully double-check the mains wiring, and all the other wiring to the power supply circuit. If possible get someone else to check the wiring as well. Never be tempted to save money by leaving out fuses, and always use a fuse of the correct type and rating.

Never work on a project while it is connected to the mains supply – remove the mains plug. Mains powered projects should be perfectly safe provided you adhere to the basic safety precautions and do not “cut corners”.

Go to next section

Circuit Surgery

by ALAN WINSTANLEY

Single transistor common emitter amplifiers come under our surgeon's microscope, along with a follow-up on opamps.

Before we continue with our in-depth look at opamps, first a couple of interesting questions from Mike Tinker via email.

TEACH-IN AMPLIFIERS

Hopefully, readers and electronics novices everywhere are already engrossed in our latest educational tutorial – *Teach-In 2000*, written by our own Technical Editor John Becker. The series is specially written for beginners and includes an interactive computer program, which runs on virtually any IBM-compatible PC. The *Teach-In 2000* software is available free from the *EPE* Online Library site at **www.epemag.com**

Previous *Teach-In* series still continue to be popular as well – our *Teach-In '93* series was prepared for GCSE and Advanced Level electronics students. We developed a modular-built test-bed called the *Mini Lab* (still available from Magenta Electronics – see their ad. elsewhere in this issue). An optional add-on *Micro Lab* microprocessor demo unit was also produced for more advanced readers, and the entire series was re-published as *Teach-In No. 7*, which is still available from the *EPE Online Store* – see the "Books and CDs" page on the *EPE Online* web site at **www.epemag.com**

Reader ***Mick Tinker*** writes by E-mail:

Whilst flicking through EPE *I noticed the* Teach-In No. 7. *I thought my electronics skills could do with some dusting off and thought there is no better place to start than at the beginning. I then immediately discovered the Mini Lab, which I am thoroughly enjoying building and doing the experiments – my involvement and interest in electronics has laid dormant for many years but is once again alive and kicking! Please could you help with some questions as follows.*

Teach-In No. 7 *talks about the "10% Rule'' for potential dividers. I tried an experiment with a 5k6 resistor and LDR (light dependent resistor), which I'm trying to use as a potential divider with a 5V supply to drive a light-emitting diode (yes – LED).*

The LDR has a resistance of 29k (kilohms) in the dark. However, there is insufficient current to drive the LED How can I arrange this so that 10mA

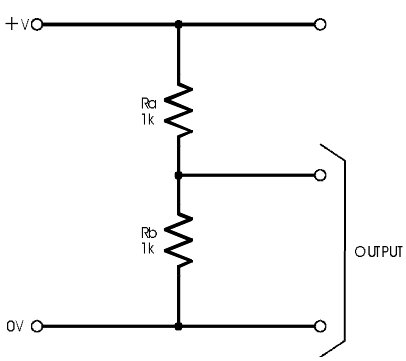


Fig.1. A simple potential divider. The output voltage is calculated using the standard formula V_O = Rb/(Ra+Rb) x supply voltage.

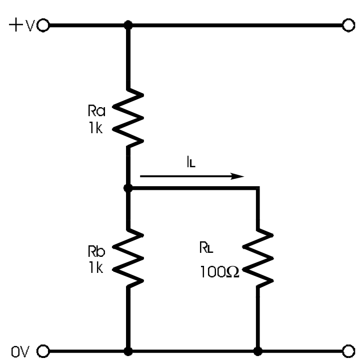


Fig.2. The load resistance R_L shunts the resistor Rb and causes a load current I_L to flow out of the divider.

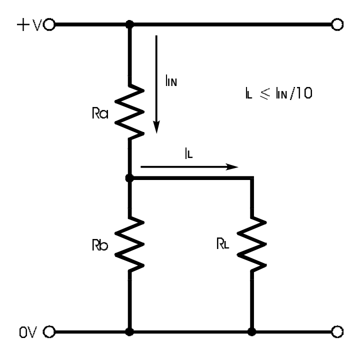


Fig.3. The "10% Rule" says that the load should not affect a potential divider unduly – ideally R_L should be at least ten times the value of Rb.

is available to drive the light-emitting diode without loading the divider? Or should I try a different LDR?

Can you also help with common emitter amplifiers. How does such a circuit work with regard to any subsequent amplifier stages? Could you clarify what happens to the bias voltages which are set up using resistors and potential dividers.

The "10% Rule" for potential dividers is depicted in Fig.1 to Fig.3. If you strap two resistors across a supply voltage then a potential divider is produced, Fig.1. The voltage across each resistor is proportional to the resistance value, so if Ra and Rb are one kilohm (1k) in value, then with a 10V rail, 5V would appear across each resistor. Usually, it is the potential divider's "output" voltage with respect to 0V that we are interested in, so we would say that this potential divider has an output of 5V.

This is fine provided that no "load" current is drawn from the output of the potential divider. If any current (shown as I_L in Fig.2) is drawn then the equation for calculating the output voltage is affected.

Imagine that we now place a load resistor R_L in the shape of a 100 ohm resistor on the output. What happens? Simply, it is placed in parallel with Rb, whose value is now "shunted". It reduces in resistance, so the voltage divider output must start to fall.

Using the formula for calculating the resistance of any two resistors in parallel:

$$R_P = (Rb \times R_L) / (Rb + R_L)$$

the value of Rb is modified by the presence of R_L to form a 90·9Ω resistor so, unless we now take R_L into account, our potential divider formula (Fig.1.) no longer holds true. The 10% Rule says that it's OK to add a load to a potential divider this way as long as the current I_L flowing out of the divider is no more than roughly 10 percent of the input current, see Fig.3. As a general rule of thumb, the load R_L should be at least ten times greater than Rb, or you will affect the potential divider.

OVERRULED

It is very important to understand that in practice, the load resistor R_L can represent a much more complex circuit, including the input impedance of a subsequent amplifier stage. Similarly, resistors Ra and Rb could be the output impedance of a preceding amplifier stage.

The same rule holds true: provided that the amplifier does not "load" the potential divider by more than 10 percent or so, you can apply potential divider formulae with reasonable impunity. If it does, then the amplifier's bias voltages may be affected, and this could lead to distortion. Some writers aptly describe how "stiff" a potential divider is, which refers to its ability not to be unduly affected by an intended load.

Mike Tinker quotes values of 5k6 for the resistor and an LDR of 29k and clearly there's a problem with the available current. With a 5V rail the current flowing into the divider will only be 0·14mA. Under the 10% Rule, the maximum load current we can safely draw is even less – a meager 14uA.

The only solution is to "buffer" the potential divider by adding an amplifier stage, such as an opamp. A CMOS-input opamp would act as a suitable load for the potential divider, because the opamp's input resistance is incredibly high: so high that you can ignore the current flowing into its input. This means it will not load the potential divider whatsoever, see Fig.4. The opamp has a gain of one (it's a unity gain buffer) and its output can then be used to drive a LED if that's what you wanted to do.

COMMON EMITTER AMPLIFIERS

Your second point relates to "common emitter" amplifiers. How can a transistor actually amplify a voltage? A single-transistor amplifier is shown in Fig.5, which Mike noted from our *Teach-In No. 7* book. Resistors R1 and R2 set a voltage at transistor TR1 base (b) of 1·7V and approximately 0·7V is dropped by the base-emitter "diode" (junction), meaning that 1·0V appears across the emitter (e) resistor R4.

Using Ohm's Law, a current of 1mA passes through resistor R4, so a voltage of 5·6V appears across resistor R3 (see

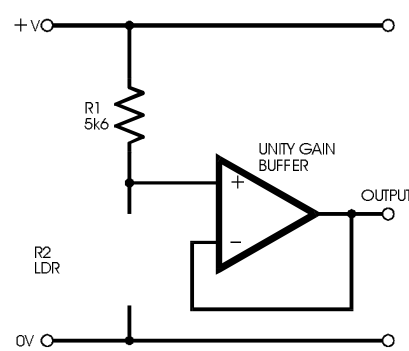


Fig.4. An opamp can be used to act as a "buffer" and avoid loading the LDR at all.

Fig.5). With a 12V rail, this leaves 5·4V across the transistor between collector and emitter (the formula *P=IV* says that TR1 dissipates 5·4mW at this time).

Note that the gain of this stage is:

–Vout / Vgain

(the minus indicating that the output signal is inverted, or the opposite polarity to the input).

Let us suppose the base voltage *rises* by 0·5V to 2·2V, so the voltage across R4 rises too and the current through the collector/emitter increases as well. You can soon calculate that the voltage across R3 must rise to 8·4V as a consequence.

This amplifier's output voltage *falls* dramatically for a small *increase* in input signal. In Fig. 5, a change of 0·5V input causes a change of –2·8V, so the amplifier's gain is –5·6. It is no coincidence that this gain figure is also the ratio of R3/R4.

A coupling capacitor C1 is used to apply the alternating input signal. A capacitor is good at letting AC signals pass, but blocks any DC content, so the effect of C1 is to allow us to "superimpose" the alternating signal onto the steady DC bias voltage at TR1 base. It ensures that TR1's base voltage is separated from any DC bias voltages on the input side of C1.

To answer your final query, an amplifier stage has its own "local" bias voltages, but by using capacitors to couple stages together, the alternating signal can be shifted along from one stage to the next without interfering with (or being affected by) these bias levels.

Of course, the designer needs to ensure that there is sufficient "headroom" to permit the amplified signal to swing between ever increasing voltage levels. Otherwise the signal will be clipped, which will cause distortion. This is explained with practical examples in the *Teach-In No. 7* book – see the "Books and CDs" page on the *EPE Online* web site at **www.epemag.com**. *ARW.*

MORE ON OPAMPS

Now we return to the opamp extravaganza. Recall that last month ***Mohab Refaat*** asked how to select an opamp for a particular application out of a large number of candidates. Also, ***Tony Soueid*** wanted to know about the innards of opamps.

We continue now by looking at opamp specifications: it is these parameters that designers of opamp circuitry will strive to meet, so it helps to know what they are before we look inside the opamp itself.

ELECTRICAL RATINGS

Maximum Differential Input Voltage: The maximum value of (V_2-V_1) which can be applied (see Fig.2 in last month's *Circuit Surgery*).

Typically this is equal to the supply voltage or is a largish value such as ±40V. In a few cases it may be much lower, less than ±1V, for example. You will need to take note of this if your application causes large differential inputs to occur.

In actual operation, the differential input voltage is often very low due to the high gain of the opamp. Consider an opamp with a gain of 1 million operating on a ±10V supply. The maximum output voltage will be ±10V, which only requires a differential input of ±10uV (ten microvolts). A differential input larger than this will cause *saturation* – that is, the output cannot go any higher (10V in this example).

Amplifiers, filters, and similar signal processing circuits use the opamp in this way, but other circuits such as comparators and some types of oscillator may use large differential inputs, which switch the opamp between positive and negative saturation. Fig. 3 (last month) shows the relationship between opamp differential input voltage and output voltage.

Saturation should usually be avoided in circuits that must operate at high speed as the opamps take longer to recover from saturation than to respond to signals within their linear operating range.

Maximum Input Voltage: The maximum V_1 or V_2. Like maximum differential input voltage, this is often specified in terms of the applied supply voltage.

Maximum and Minimum Power Supply Voltage: (or Supply Voltage Range) The maximum is typically ±15V to ±18V for dual supplies and 3V to 36V for single supplies, but some devices have a much lower maximum voltage (e.g. ±6V). The minimum voltage is typically ±2V to ±3V for opamps with ±15V maximum supplies, but this varies quite a bit.

There are a number of low voltage opamps that have

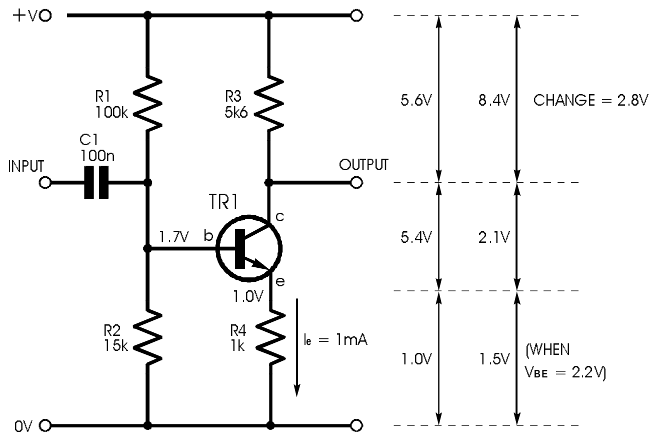


Fig.5. A common-emitter amplifier. A change of 0·5V on the input produces a change of 2·8V across resistor R3. Its gain = –5·6.

minimum supply voltages down to ±1V or less. These are usually designed for low power applications.

Exceeding maximum supply voltages can cause damage to integrated circuits due to excessive current flow and power dissipation. This can even occur with short over-voltage transients that can cause the circuit to latch in a state where high supply current flows even after the supply has returned to its normal level. However, great care is taken with most integrated circuit designs to make sure this does not tend to happen.

Power Dissipation: The product of supply current and supply voltage.

Power dissipation will increase as the power supply voltage is increased and if higher output currents are demanded from the opamp.

If an opamp is available in more than one type of package these may have different power dissipation ratings. For special low power (micropower) opamps, the amount of power consumed in typical operation is often quoted. For most opamps the *maximum* power dissipation that can occur without causing damage is quoted.

We'll press on with more "inside information" about opamps next month. *IMB.*

Go to next section

Shop Talk

with DAVID BARRINGTON

Some Component Suppliers for EPE Online Constructional Articles

Antex
Web: **www.antex.co.uk**

CPC Preston (UK)
Tel: +44 (0) 1772-654455

EPE Online Store and Library
Web: **www.epemag.com**

Electromail (UK)
Tel: +44 (0) 1536-204555

ESR (UK)
Tel: +44 (0) 191-2514363
Fax: +44 (0) 191-2522296
Email: **sales@esr.co.uk**
Web: **www.esr.co.uk**

Farnell (UK)
Tel: +44 (0) 113-263-6311
Web: **www.farnell.com**

Gothic Crellon (UK)
Tel: +44 (0) 1743-788878

Greenweld (UK)
Fax: +44 (0) 1992-613020
Email: **greenweld@aol.com**
Web: **www.greenweld.co.uk**

Maplin (UK)
Web: **www.maplin.co.uk**

Magenta Electronics (UK)
Tel: +44 (0) 1283-565435
Web: **www.magenta2000.co.uk**

Microchip
Web: **www.microchip.com**

Rapid Electronics (UK)
Tel: +44 (0) 1206-751166

RF Solutions (UK)
Tel: +44 (0) 1273-488880
Web: **www.rfsolution.co.uk**

RS (Radio Spares) (UK)
Web: **www.rswww.com**

Speak & Co. Ltd.
Tel: +44 (0) 1873-811281

Versatile Burglar Alarm

Looking through the components list for the *Versatile Burglar Alarm* project, a few decisions will need to be made by readers as to the complexity/cover they wish to have as this will have a considerable effect on the costing of the project. This applies particularly to the separate listing of the alarm devices.

Starting with the main listing. The bridge rectifier used in the prototype unit is a type W005 and should be generally available. Most component suppliers should be able to offer a suitably rated 20VA mains transformer. Also, note that the type BC184**B** transistor must be ordered (base being the center pin) and ***not*** one with the suffix L.

The DIL type 12V 2-pole miniature relay was purchased from Maplin, code GU36P. The stripboard for this circuit will have to be cut down to size from a larger piece.

Turning our attention now to the alarm devices, readers may wish to investigate some "security" component suppliers, such as Suma Designs, ASA, or general component suppliers like Bull Electrical, Chevet Supplies, or J&N Factors, who sometimes carry warning sounders, pressure mats, vibration sensors, magnet-operated reed switches etc. at special discount prices.

The warning devices used in the prototype came from Farnell, order codes as follows: siren/klaxon 676-843; alarm bell 107-843; bell enclosure 149-797; and 12V xenon strobe beacon 223-712. The miniature reed switch (code CI37S) and operating magnet (code FX71N) both came from Maplin.

Scratch Blanker

The only real cause for concern when getting together parts for the *Scratch Blanker* is more than likely to be in finding a source for some of the semiconductor devices. Most of the other components for this project should be available from your usual local supplier or by mail order.

If any readers do experience problems in obtaining the MN3004 512-stage "bucket-brigade" delay line and its companion MN3101 clock generator/driver ICs, the author obtained his from Maplin (quote codes UM64U and UM66W respectively). Incidentally, in case you are wondering about the connecting of the "ground" pins to the positive supply line, these two chips are PMOS devices; mystery solved.

The above company also supplied the small double-pole mains rotary switch, code FH57M. The original mains transformer used in the prototype came from ElectroValue, type BR515 rated 5VA, but as it is mounted off-board most component suppliers should be able to

match its electrical characteristics. They will probably offer a 6VA type.

The 8-pin low power TS555CN timer should be used in this circuit and is widely stocked (it is not advisable to use a standard 555). It is also best to stick with the NE5532N high quality audio amp IC in this project. Both the 4066 and 4016 analog switch ICs are popular, well stocked, devices.

The large printed circuit board is available from the *EPE Online Store* (code 7000250) at **www.epemag.com**

Flashing Snowman

Our "starter project" this month has a timely festive theme and all the components (tile excluded) needed to make up our *Flashing Snowman* should be readily available from components suppliers. They will also be able to offer a suitable stabilized mains adapter unit at a reasonable price if the *Snowman* is to be left "running" for long periods.

Note that the LEDs should all be of the same type and size, and that electrolytic capacitor C2 should be a new good quality component. The translucent type of LED seems to be fairly widely stocked and should not be a serious sourcing problem. The TL071 opamp and the two transistors should also be stock items.

The *Flashing Snowman* is easily built up on our multi-project printed circuit board, which is available from the *EPE Online Store*, code 7000932. As for the polystyrene tile, a trip down to your local DIY store should soon sort this one out.

Vehicle Frost Box

We cannot foresee any component buying problems for constructors of the *Vehicle Frost Box* project. They all appear to be "off-the-shelf" items. The only point we would highlight is the use of heavy-duty auto-wire for the unit's power supply leads. This should be obtainable from any good motoring store.

Teach-In 2000

No additional components are called for in this month's installment of the *Teach-In 2000* series. For details of special packs readers should contact:

ESR Electronic Components – Hardware/Tools and Components Pack.

Magenta Electronics – Multimeter and components, Kit 879.

FML Electronics (Tel +44 (0) 1677-425840) – Basic component sets.

N. R. Bardwell (Tel +44 (0) 114 255-2886) – Digital Multimeter special offer.

PLEASE TAKE NOTE: *8-Channel Data Logger, Aug/Sept '99*

An updated software version V1.2 became available in the EPE Online Library on 29th November 1999.

Go to next section

DIGITAL TV'S PROBLEMATIC FUTURE

Yet again different standards pose a threat to technology's development.
BARRY FOX REPORTS.

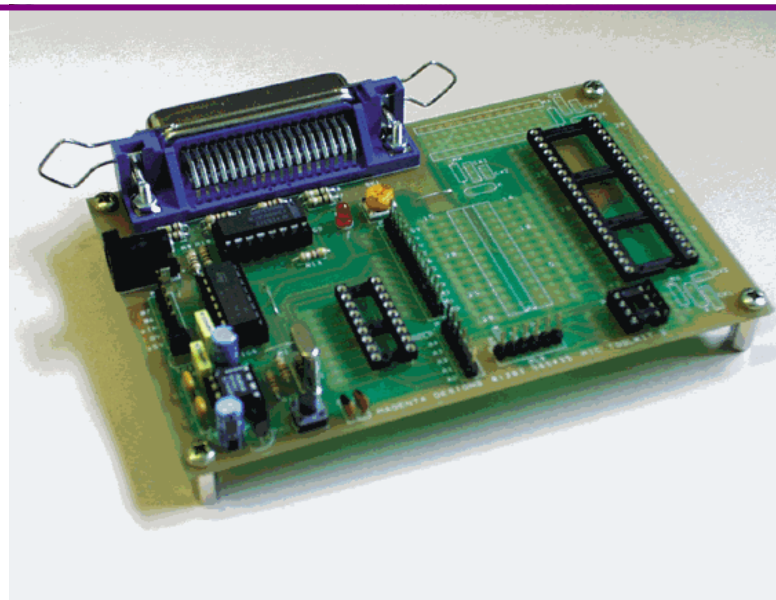
The US government's plan to convert from analog to digital TV by 2006 is now *"in disarray and on the verge of collapsing",* warns Strategy Analytics (formerly BIS Mackintosh). The international research company previously and correctly predicted that the Divx limited-play DVD system would flop. *"Less than five per cent of households will be watching DTV by 2005",* says SA's David Mercer.

The European and US governments want to switch viewers onto digital viewing so that they can sell off the liberated analog frequencies for more TV or mobile radio. But the two Continents have adopted radically different approaches.

1250-LINE FAILURE

Ten years ago the European Commission tried to convert European viewers from 625-line PAL TV to the 1250-line high definition MAC system. HD-MAC flopped because viewers did not want to buy the expensive new widescreen HD receivers needed. Learning from this mistake, Europe has adopted digital standards initially based on 625 lines.

DVB, developed by the Digital Video Broadcasting Group in Geneva, lets viewers plug a new set-top box between a terrestrial antenna and existing TV set. DVB has the option to heighten resolution in the future



MAGENTA TOOLS UP

With the PIC16F877 well and truly available from Microchip (you may recall that its introduction was much delayed), Magenta Electronics have produced a kit of components for the EPE PIC Toolkit Mk2 (May/June '99), including a revised version of the PCB.

Magenta's PCB is very similar to that published in EPE Online but, following suggestions from Toolkit's author John Becker, has some new features included. Principally, these entail the separation of the combined socketing for IC3 into two sockets, one each for the two PIC16F87x package sizes.

Additionally, connection points have been added to each of the pins for both new IC3 sockets, allowing external circuits to be connected directly to Magenta's board. The option to install separate crystal control components for the two IC3 version sizes has also been added.

In common with other Magenta produced boards, all component position notations have been silk-screened onto the upper side of the board. The underside is solder-resist coated.

For more details, contact Magenta Electronics Ltd., Dept EPE, 135 Hunter Street, Burton-on-Trent, Staffs, DE14 2ST, UK.

Tel: +44 (0) 1283-565435

Fax: +44 (0) 1283-546932

if the public think it is worth buying new sets.

DVB uses COFDM, Coded Orthogonal Frequency Division Multiplex, which spreads the broadcast signal between several thousand narrow carriers. This slows the data rate in each stream and lets the receiver reject unwanted signal reflections or "ghosts". Terrestrial DVB can work with a set-top aerial or mobile receiver.

Any viewer in the UK can now get a DVB box free if they subscribe to a pay-TV service. After one year nearly 0.5 million DTTV boxes are in use. The Sky digital satellite service also uses 625 lines and carries most of the digital terrestrial channels free to around 1.8 million set-top boxes.

GHOST BUSTERS

The US government's Federal Communications Commission and its Advanced Television Standards Committee preferred a high definition digital system, tailored to the hierarchy of display standards used by PCs. The FCC also opted for Vestigial Sideband transmission, a more simple technique than COFDM, similar to that used for North America's 525-line NTSC analog TV.

The VSB system carries the TV signal at high data rate in a single channel, so it is much more susceptible to echoes than a COFDM signal. The echoes corrupt the bitstream.

US set-makers are trying to improve reception with ghost-canceling circuitry, as pioneered by the UK's Independent Television Commission in 1993.

Reference pulses, like a radar "chirp", are broadcast along with the TV signal, and the TV set has a memory which permanently stores an image of the pulse. The set continually compares the reference and received pulses. This reveals the echo characteristic, and the set uses this tell-tale information to cancel out the delayed TV signal.

The ITC was stymied because chips could not work fast enough to cancel in real time. Seven years on, the US set-makers have a better chance of making the system work, and making VSB do what COFDM does naturally.

VIEWERS WON'T PAY

US viewers are now baulking at the need to spend several thousand dollars on a new TV set that can decode digital signals and display them in higher resolution. Set-top antennae do not work.

US broadcast chain Sinclair has rallied 400 stations, more than a third of all US commercial broadcasters, to ask the FCC for permission to use COFDM instead of VSB. Nokia of Finland has built COFDM receivers for the US broadcasters' tests.

CEMA, the Consumer Electronics Manufacturers Association, argues that poor reception is the fault of poor sets, not VSB. CEMA President Gary Shapiro warns that splitting the standard would have *"devastating results for the DTV transition".*

Says David Mercer of Strategy Analytics in Boston, MA, *"Analog broadcasting is an anachronism, but switching off NTSC is going to be a far greater challenge than most people realize''*.

He predicts that terrestrial broadcasters in the US will end up using their digital capacity for data services.

SKY ELECTRONICS

Colorful and comprehensive are our first reactions in receipt of the latest catalog from Sky Electronics. There are over 140 pages of full-color details of an enormous and diversified range of products. It is a catalog that will delight anyone who is into ready-made equipment and the accessories that maintain it.

The main titles of the sections include Audio and Video, Music and Disco, Car, Communication, CCTV, Electrical, Computer, Test, Power Supplies, Tools, Connectors, Cable, Loudspeakers.

Each of these sections is filled with beautifully photographed products that really show off the product quality and desirability. Where detailed specifications are required, these are well-itemized. All products have code reference numbers and the prices are then cross-referenced in an accompanying 16-page list.

Sky tell us that they also stock a massive range of other components, including semiconductors, capacitors, resistors, video parts, remote controls etc., all *at "what we believe are very reasonable prices".*

For more details contact Sky Electronics, Dept EPE, 40-42 Cricklewood Broadway, London NW2 3ET, UK.

Tel: +44 (0) 20-8450-0995

Fax: +44 (0) 20-8208-1441

VINTAGE RADIO SALE

Recently, a sale of Vintage Radios, the Duncan Neale Collection, took place at Donnington Priory, Newbury. It thoroughly confirmed that vintage radio equipment continues to be much sought after.

Top price of the day was achieved for a Marconiphone receiver, which fetched 3000 UK Pounds. This was a fascinating set, seen to the bottom right of the photo, with the cabinet very finely japanned in oriental style. Two other four-figure prices were tendered for pre-broadcasting items, one of them a tuner from 1918. Even vintage crystal sets were fetching in excess of 200 UK Pounds, one example reaching 520 UK Pounds.

Duncan Neale had concentrated his collecting on the early broadcasting years of the 1920s and into the 1930s but he also had a small group of much later communications receivers. These were unexpectedly well received!

Auctioneers Dreweatt Neate tell us that at the end of an exciting afternoon, all but two of the 244 lots had sold for a total of over 45,000 UK Pounds, comfortably in excess of the top estimate. The innovative live presence of the Internet was felt in that at least 15 lots sold to Internet bidders, who were also active underbidders on other items. Clearly a pointer to the future.

For more details, contact Dreweatt Neate, Donnington Priory, Donnington, Newbury, Berks RG14 2JE, UK.

Tel: +44 (0) 1635-553553

Fax: +44 (0) 1635-553599

Web: http://dreweatt-neate.co.uk

TAPE DROPS IN EASILY

Premier Elmech remind us that we've probably all experienced old or "tired" cassettes – they don't run smoothly, the sound is distorted, tape spills out, or wraps itself up inside. These happenings are due to tightness within the cassette case, which can result from a number of causes.

To combat this effect, Premier Elmech have developed a specially formulated lubricant which is said to restore the treated cassette to its former glory. The lubricant is non-toxic, non-flammable and will not affect the rubber drive belts, the tape, or any adhesive tape joins.

The lubricant is supplied in a 10cc dropper bottle, which dispenses the correct quantity to treat one cassette hub at a time, and contains sufficient to treat upwards of 50 cassettes. A hand-operated cassette winder is included to enable the treatment to be accomplished outside the machine. The cost is 4.50 UK Pounds, including VAT and postage.

For more details, contact Premier Elmech, 65 High Town Road, Luton, LU2 0BW, UK.

Tel: +44 (0) 1582-611991

Fax: +44 (0) 1582-611911

E-mail: premier@interdart.co.uk

FML ELECTRONICS CATALOGUE

Another catalog received is that of FML Electronics. Comprised of five A4 pages of closely type-set lists of components, this cat contains masses of items for which readers will be frequently on the look out. Semiconductors are heavily featured on pages 1 and 2, from discretes through digital and analogue ICs to PICs.

The other pages include capacitors, crystals, connectors, cases, all sorts of hardware, including switches and stripboard. Page five features a selection of development and "popular assortment" packs.

Separately enclosed with the main cat sent to HQ were details of FML's very wide range of kits for EPE Online projects, including not only those for Ingenuity Unlimited designs, but also for our current *Teach-In 2000* series.

For more details contact FML Electronics, Dept EPE, Freepost NEA3627, Bedale, N. Yorks DL8 2BR, UK.

Tel: +44 (0) 1677-425840

PICO CAT

Pico Technology's latest catalog has been received, covering the period for Sep '99 to March '00. As many of you will know, Pico have become leaders in the field of virtual instrument technology solutions. Their range of PC-based instruments covers oscilloscopes, spectrum analyzers, meters, data acquisition, environment monitoring and signal conditioning. The entire range is extensive, and of excellent quality and value. Amongst the selection of accessories shown in Pico's cat is a dual parallel port for only 15 UK Pounds. If you are one of the (few) readers who cannot get your PC parallel port to function with some of our published software, this interface might provide you with a solution.

New products in this catalog include a higher-speed thermocouple to PC converter, and some more signal conditioners.

For more details, contact Pico Technology Ltd., Dept EPE, 149-151 St Neots Road, Hardwick, Cambs CB3 7QJ, UK.

Tel: +44 (0) 1954-211716

Fax: +44 (0) 1954-211880

Email: post@picotech.com

Web: www.picotech.com

SHERWOOD CAT

Sherwood Electronics have been advertisers with the hard copy edittion of EPE for many years and it's good to receive and publicize their latest catalog, that for the year 2000, appropriately sub-titled "The Millennium Edition". Containing around 100 pages in A5 format, this catalog of essential electronic components is one which ought to be prominently on your bookshelves or workbench.

Products include batteries, buzzers, capacitors. connectors, semiconductors galore, displays, motors, pots, speakers, switches, tools and much, much more, to just name a few groups in Sherwood's range.

The cat is cleanly laid-out with prices well-prominent, and line-drawing illustrations where appropriate. It costs 1 UK Pound, but there is 1 Pound worth of discount vouchers included. For more details contact Sherwood Electronics, Dept EPE, 7 Williamson Street, Mansfield, Notts NG19 6TD, UK.

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Readout

***John Becker* addresses some of the general points readers have raised. Have you anything interesting to say? Email us at editor@epemag.com!**

WIN A DIGITAL MULTIMETER

A 3 1/2 digit pocket-sized LCD multimeter, which measures AC and DC voltage, DC current, and resistance. It can also test diodes and bipolar transistors. Every month we will give a Digital Multimeter to the author of the best *Readout* letter.

* LETTER OF THE MONTH *

A-LIVE-A-LIVE-OH!

Dear EPE,

A friend recently drew my attention to the current series you are running on Oscillators (since July '99). Having obtained the September issue, I sent for the previous issues. What interesting reading they make!

I have been pleasantly surprised by the exchange of information with readers in *Readout*, and the informative level of *Circuit Surgery*.

I also wish to add to various previous discussions about mains electrical power lines. Being long in the tooth, I can say that I was an apprentice on the Southern Electric Board not long after Nationalization. I was involved in the huge task of replacing old equipment with new certified units. At the time there were still people with gas lighting, but many were on DC or 200 volts AC. Many of the installations used the designations Main, Line and an Earth symbol. The new equipment used Line, Neutral and Earth. There was some confusion when L, N, E was used instead of M, L, E. I believe that this confusion still exists to some degree.

All the electricians I have been associated with in industry over the last 30 years have referred to Live or Dead circuits. Only on official drawings does the label Line appear. Anyone capable of reading them understands the obvious. It is typical of standards groups to choose long winded labels that when abbreviated, result in an ambiguous Line. There is "Hold the line please!", "Shoot a line", "Cast a line", "Cloths line", and "Draw a line". I believe that bomb disposal squads refer to a bomb as Live. Sensible people with a lot to lose!

Another wonder decision was to insist that a light bulb or torch bulb (to mention just a few) should be called a lamp. To most of us, I think, a lamp is a structure or package containing a light source, which could be a wick and oil, a carbon rod and an arc, a bulb and battery, or light bulb and flexible cord. How about fluorescent light lamp? Really rolls off the tongue, doesn't it!

Arthur Lawrance
via the Net

It is an interesting fact that, despite attempts at standardization, English continues to evolve and, irrespective of "official" definitions, the perceived meaning of many words changes amongst the general population. There are many cases, too, where words have acquired different meanings depending on the context in which they are used.

It's worth remembering (or is it?!) what Alice's Wonderland friend Humpty-Dumpty said (in a rather scornful tone), "When I use a word it means just what I choose it to mean – neither more nor less"!

HIEROGLYPHS

Dear EPE,

I've downloaded the EPE Teach-In 2000 software from your website, unzipped and loaded it. It works perfectly on my machine, except that it is completely unreadable. I see from the note on EPE page 854 (Nov '99) that FTP software has to be set to ASCII transfer. Should this be done for downloading from the website, and if so, how is it done? Is FTP software something that is included in Outlook Express?

Tim Rollin
via the Net

Tim addressed his query to our On-Line Editor Alan. Here's a summary of the subsequent on-line conversation:

Alan: *Hmmmm... are you seeing funny characters? Readers have reported this once or*

twice. Explorer or Navigator will handle FTP automatically. If you fetched it as ASCII, the file would arrive broken and wouldn't run properly. You don't need to worry about ASCII/FTP. Please could you let me have more details of what you're actually seeing. Are the graphics OK but the lettering and wording weird?

Tim: Yes – the graphics seem to work fine, but the letters are a series of jumbled capital letters, numbers and characters, of which half only is visible, as if some were partly on the line above and some partly on the line below. The characters make no sort of sense and seem to be randomly distributed. The menu screen is not rectangular – the vertical sides are bowed outwards. I can move from one screen to the other fine, and back to the menu once I'd worked out that I needed to press "M"! The program is fine – I just can't read it. My machine uses Windows 95.

Alan: *Sounds like you have the Teach-In 2000 file OK, it's your PC system which may be configured for a different country or codepage, or video driver issues. I'm unsure at the moment, but one or two others have said the same sort of thing.*

Send me a copy of your config.sys and autoexec.bat, I need to look at the setup, and ask my team at Hull University. Also, are you running the software in a DOS box, or from the C:\ prompt (command prompt) – i.e. a true DOS screen without the Windows shell running in the background (not that I'm sure it will make any difference yet)?

Tim: I thought that in Windows 95, DOS was only an emulation. However, I tried the program after restarting the computer in DOS mode (that took me back!), but the program was still unreadable.

Alan: *Your codepage and country code settings are the same as the ones I use, so that cause is eliminated.*

This is starting to sound like your video adaptor is failing to display EGA text correctly. I don't think this is a codepage problem. I might be wrong, but we think your card is either non-standard or has failed in one circuit, the alternative is that there is a problem with font tables looked up by QBasic. The following display fonts are commonly used by MS-DOS, ensure they are installed:

```
CGA40WOA.FON
WA80WOA.FON
DOSAPP.FON
EGA40WOA.FON
EGA80WOA.FON
```

Try running the program in a Windows 95/98 MS-DOS box again, then force full screen mode by hitting ALT+ENTER. Repeat this again to see if it toggles back to a Windows box. A warning message will be displayed if it doesn't like the graphics mode. There may be an issue on your system when running the software in character mode rather than graphics mode in a DOS box. Try experimenting with this, and also with the MS DOS menu settings above your Windows box.

Tim: Thanks for all your efforts. I've solved the problem messily by copying all the files to an old Compaq 386, where the program works perfectly. I loaded the various font files you mentioned onto the Windows 95 machine (which is a Viglen) but it made no difference to the text. You must be right when you say there is a fault on the video adapter, but as everything else works fine, I'm loath to fiddle around with it too much.

John: *Another reader (anonymous) also made the following comment to Alan (having been following correspondence on the EPE Chat Line):*

Anon: Had a similar problem with PIC Toolkit, characters were all garbled. The cause was a faulty video card in my PC, every other program worked fine. Suspect your Teach-In 2K users may have a similar problem. A new video card solved my problem.

John: *I also had a similar problem with one machine a couple of years ago. The cause of the problem turned out to be due to a config.sys/autoexec.bat problem with the country code settings. Amending the code to that on my other machines (country code 437) solved the problem. This was the comment I made to those readers who phoned me saying they had a "hieroglyphics" problem. I am interested to note that Alan also thought that Tim's problem might be due to a similar situation, but that this turned out not to be the case.*

What also intrigues is that we have published many programs written in QBasic/QuickBASIC, many of them mine, but, with the exception of a couple of hieroglyph queries with Toolkit, there have been no reported display problems with any of them. However, it's pertinent to comment that I have an early EasyPC program that I use for all my PCB design work which runs cleanly on three of my computers, but not on two others, it too producing hieroglyphs. This despite all ma-

chines having the same apparent display settings and working perfectly with Basic in all QB and GW forms. Whilst I normally run my programs in Basic from DOS, I can also run them through Windows without problems.

We would welcome feedback from readers on this puzzling hieroglyph situation, and its definitive solution! Thanks Alan for discussing matters with Tim and for the information you've brought to light.

LISTEN WITH TOOLKIT

Dear EPE,

I am in the process of constructing PIC Toolkit Mk2 (May/June '99) and recently downloaded the software (V2.3) from your web site. Up to this time I have been using Microchip's MPASM software package including simulator with an inexpensive home constructed programmer from a kit provided by a UK electronic supplier. This system has worked well and is very fast but the programmer is limited to PIC16x84 microcontrollers.

The Toolkit Mk2 appears to provide a flexible and comprehensive way of expanding projects to incorporate the new PIC16F87x family with their substantially greater capabilities, avoiding the need for too much additional memory (my particular interest is neural networks for small mobile robots). It also provides, in my case, the opportunity to familiarize myself with the TASM version of PIC assembly language. I have been trying out the V2.3 software and it generally operates very well and is easy to use.

However, I have discovered one or two glitches running under both QB (*.BAS) and executable file (*.EXE):

1) When converting MPASM (*.ASM) files to TASM (*.ASM) files, the END instruction in MPASM never appears as in the TASM conversion. Having looked briefly at the QB program I noticed a line which appears to convert the string END to .END but have not yet discovered why the error is occurring.
2) The conversion of MPASM to TASM always closes with the error message "MS-DOS ERROR 62 ROUTE 9''. However, the conversion is always completed with exception of points 1 and 3.
3) Labels in my MPASM source code that start with the alpha characters LISTxxxx (e.g. LIST, LISTEN, LISTVAL) do not translate to TASM as labels. Instead they appear after a semicolon as in a comment statement. Subsequent statements such as GOTO LISTxxxx are also prefixed with a semicolon.

Since LIST is a functional command in QB, usually prefixed by other code, I wondered whether this is an inherent limitation of the software, although I have tried changing the label in the MPASM code to other QB commands such as RUN or VAL to see what happens but they translate satisfactorily with no problems. I would welcome any comments or information you might have.

I am looking forward to completing this programmer which I am sure will provide substantial scope for much more complex projects.

Christopher Knight
via the Net

Neither points 1 nor 2 have occurred with the MPASM files I've converted from time-to-time. These two problems seem related, however. DOS Error 62 is "Input Past End of File" (ignore Route 9, that's for my info only). If your input file is terminating early, then the END statement may not be received by Toolkit, hence the omission on the conversion file.

Examine the MPASM text file through DOS EDIT and ensure that END is indented and clear of other statements. Remove any strange characters that might also be part of your text file. There is one ASCII value that can be a problem on occasion, value 26 decimal (hex $1A) which is the "end of file" marker. Toolkit does not have an intercept for this code (though one day I might add one).

LIST is a reserved word used by MPASM to indicate such matters as PIC type and radix, etc. Toolkit constantly looks for this group of four letters (which as you've found might precede other letters as well) and takes any necessary action as specified after it in relation to MPASM's protocols. Having done that, the line is then "commented out" with a semicolon to avoid confusion to TASM.

TRUMPET VOLUNTARY

Dear EPE,

In the two years or so since I first subscribed to EPE, I've enjoyed reading the magazine tremendously. It's certainly the best edited of the four or so electronics magazines I read regularly, and I find the Teach-Ins very valuable. Keep up the good work!

Professor John Hagge
Iowa State University
via the Net

Thank you Professor John, appreciation is appreciated!

There was a time, though, when we were reluctant to blow our trumpet too loudly by publishing the complimentary letters received. Such self-praise when seen in other magazines can become tedious. However, the situation has changed somewhat in that we have many new readers joining us from around the world (principally through our Internet presence) and we know that they are unlikely to be aware yet of our longstanding good name, acquired over 30-odd years of existence.

At present, we feel that it is in our interests to occasionally boast a bit to these new-comers (old-comers already know our merits!) by telling them what others think of us. (In case you've ever wondered, we never invent letters for Readout – they are all genuine, although we may well edit them for length, grammar or spelling.)

KEEP ON PIC'N

Dear EPE,

The reason I subscribe to EPE is because it has more PIC projects than any other magazine that I am aware of. I subscribe to at least five other electronics-related magazines and they cannot touch what you offer regarding the PIC. Thank you!!!

I took an embedded controller course for my bachelors degree at Northern Michigan University (USA) using the PIC. That course changed my whole outlook on electronics. This versatile chip opened a whole new world of projects and experiments for me and the other students. What an eye opener! It revived my interest in electronics.

In your Nov '99 issue you gave an Editorial on how some readers are not embracing the PIC. Well, this is my testimonial and letter of encouragement to the readers that learning to PIC is not all that hard and it is a very cheap hobby to get started in. It can and will open so many more doors in the world of electronics. Keep on PIC'n!

Steve Patterson
Lake Orion, USA
via the Net

My feelings entirely – although my interest in electronics has never wavered, I have found that the challenge of writing control programs, whether in PIC or other languages, has opened up a whole new realm opportunities for me.

MS-DOS ERROR 5

Dear EPE,

When using PIC Toolkit V2.3 and attempting to assemble one of my own .ASM files, I kept getting MS-DOS Error 5. Further investigation revealed that the software would not recognize the following command: MOVLW ','. When the line was changed to MOVLW 44 (44 is the ASCII value of a comma) the program assembled okay.

Keep up the excellent work with the magazine.

Stuart Pearson
via the Net

There was I thinking that V2.3 was bug-free! MS-DOS Error 5 is "Illegal function call", and I can see what causes the problem, but amending it through a version V2.4 will have to wait until another year! It is basically to do with an intercept for commas which Basic will not import through normal string input commands. In itself the intercept is OK but I made an oversight in what would happen when another intercept is actioned for the same command line, that for specifying characters within single quotes. The end result is that Basic then tries to return an ASCII value for a null string – which it can't do. It's a bit more complicated than that, but that's the gist of it.

The problem, now that I see it, will also manifest itself through the use of constructions such as MOVLW '\ ' and MOVLW ';'. For these "quoted" characters, backslash and semicolon, their ASCII values should be used, i.e. MOVLW 92 and MOVLW 59.

TEACH-IN AND PSION

Dear EPE,

I've recently downloaded your *Teach-In 2000* (Nov '99, current series) software and had no problems running it on a modern PC. I've tried also running it on an XT emulator but it fails to load. I get the following error "Illegal function call in module TY2KMENU at address 1153:0041". Can the software run on an old XT, or only on a '286 and above?

I currently run your TASM software on the XT emulator on a Psion Series 5 (Palmtop) so that I can write PIC code and compile while on the move. I would also like to run the *Teach-In 2000* application on the Psion but this will not work if the requirements are for a higher spec machine than an IBM XT. I'm aware that the emulator has its limitations and that you can't possibly know what it's

doing, but I can only ask…

Federica Appolloni
via the Net

And I can only answer… negatively, I regret. I have run the TY2K software on '386, '486 and Pentium based desk-top machines, under Win3.1 and Win95, but I do not know how other machines/systems will cope. I would expect, though, that Microsoft (who wrote the QuickBASIC version 4.50 software which I used to write the program and compile it to a run-time .EXE stand-alone format) would have made their software compatible with as many machines as were current at the time the software was first released. By-and-large, I have found commercial software to be nearly always upwards compatible. Does any reader know an answer for Federica?

HUMOUR*ii*

Dear EPE,

Correspondents, including me, can say anything we like. We have no responsibility. if we are wrong, sooner or later someone will sort us out. So after reading the comments on my "quibbles" (Readout Aug '99), I resisted the temptation to leap back into the fray.

Professional writers, on the other hand, do have a responsibility to get things right. So, after seeing viri/virii offered once again as alternatives (Net Work Nov '99), here I am again. If I said "mans" or "oxes" instead of "men" or "oxen", you wouldn't say I was choosing an acceptable alternative, you'd say I was just plain wrong. The same applies to virii. Second declension Latin nouns ending in -us have their plurals in -i, and that is that.

I hope I am not being too one-eyed (forgive the pun) about this. For what it is worth, I have a theory about it. Perhaps "radius", with its plural "radii'', accounts for the wide-spread misconception that other words ending in -us take -ii in the plural. The point, of course, is that the first -i in "radii'' is part of the stem, and only the second i is the plural ending.

Peter Kelly
Woombye, Queensland
Australia

Apart from electronics, one of the things I am interested in is language, especially its origins, but also in its use (and misuse, either unwittingly or purposefully). Whilst my colleagues and I try to be correct with our grammar and spelling (puns and other words-play excluded!), as I implied in my Readout reply to your original letter, we do not claim perfection in this matter.

However, you read far more into Alan's Net Work "misuse" of "virii" than you should. One characteristic of the English is that we are prone to making fun of our own foibles. Alan has a keen sense of humor and by using the word in the context of what he was saying, he was humorously (humoriily?) commenting on his own previous misuse!

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